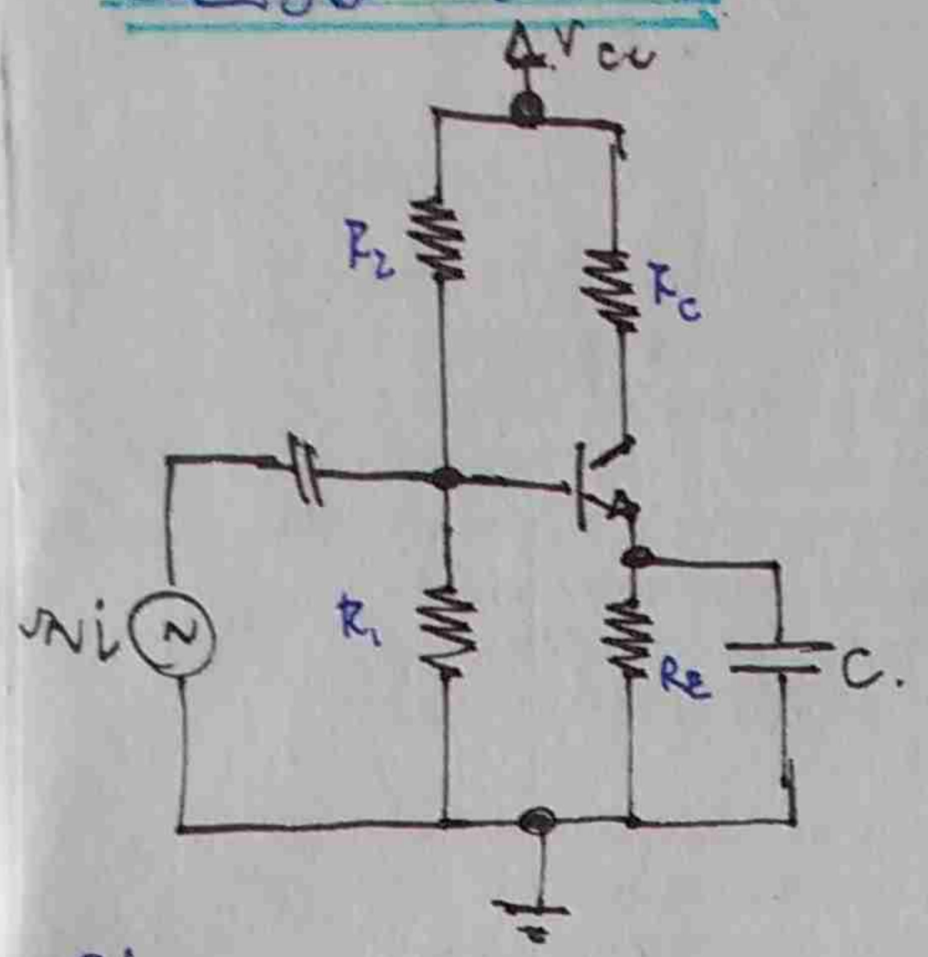
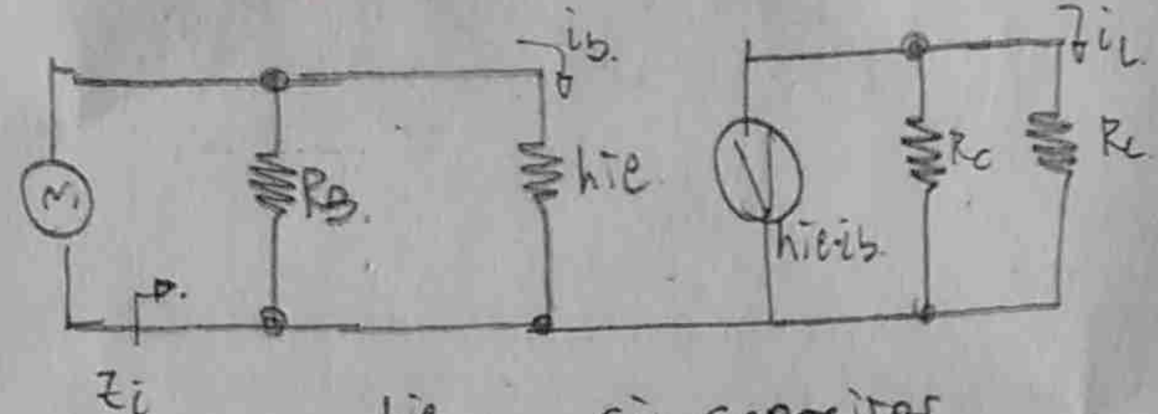
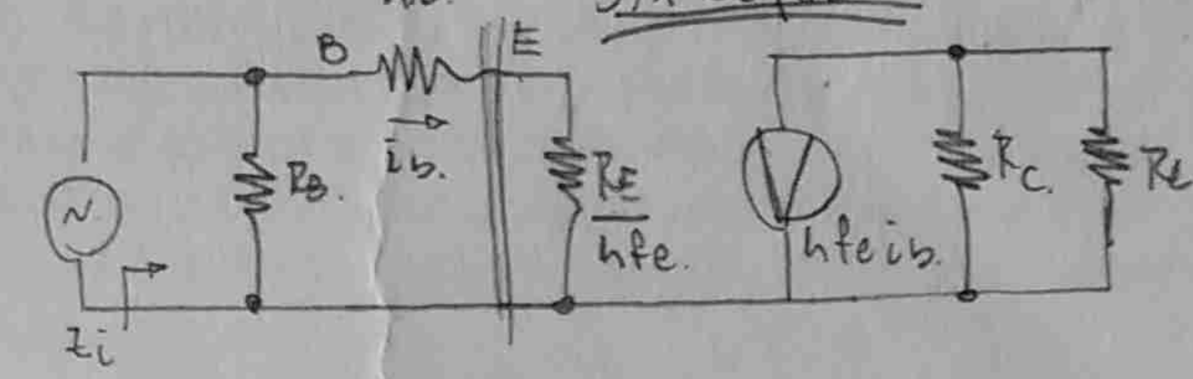
Emisor común



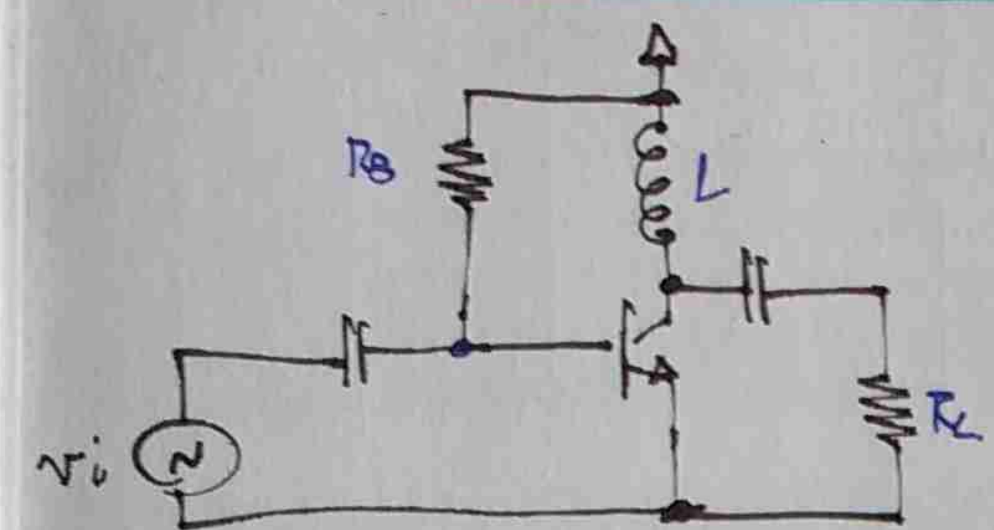
Con Capacitor



sin capacitor

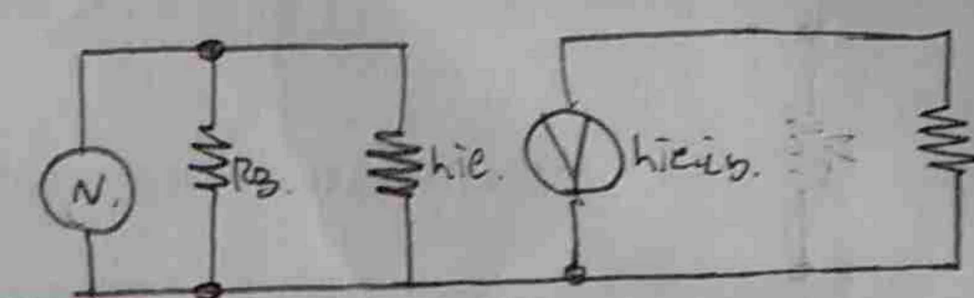


Clase A con Transformador



$$\boxed{FM = 2 = \frac{P_{C\,max}}{P_{L\,max}}}$$

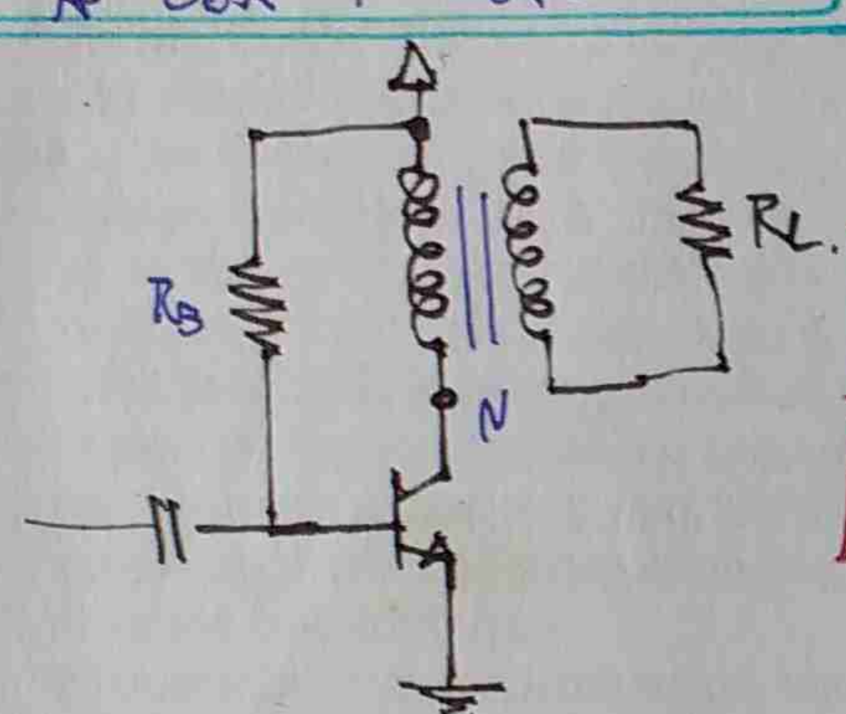
$$\boxed{I_{CQ} = \frac{V_{CC}}{R_L}}$$



$$\boxed{P_{C\,max} = \frac{V_{CC}^2}{R_L}}$$

$$\boxed{P_{CC\,max} = \frac{P_{L\,max}}{2} = \frac{V_{CC}^2}{R_L} = V_{CC}\, I_{CQ}}$$

Clase A con Transformador

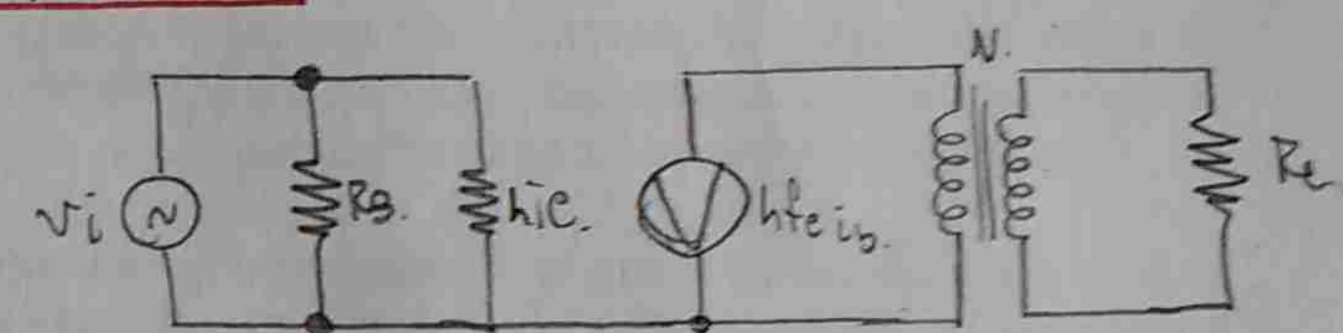


$$\boxed{R'_L = N^2 R_L}$$

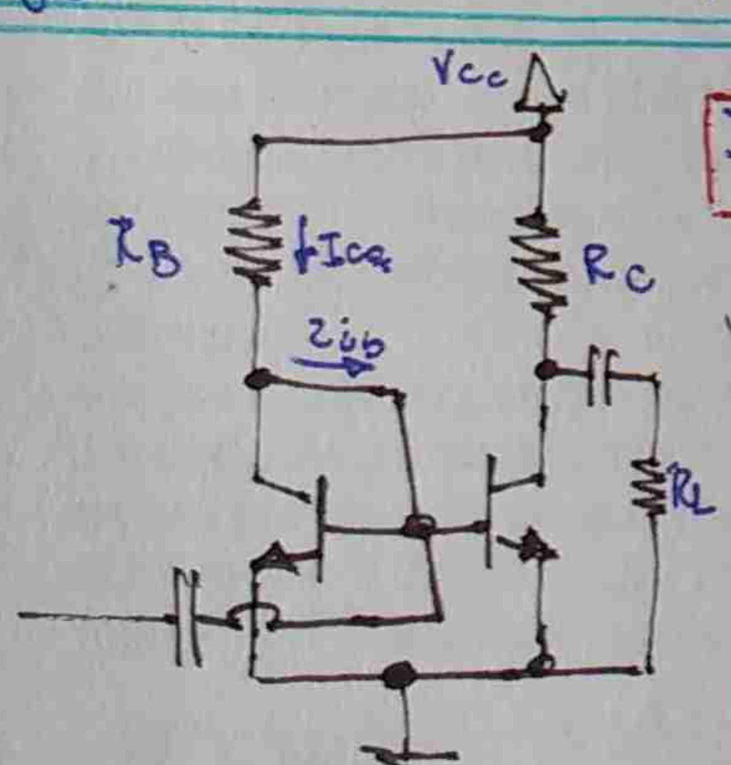
$$\boxed{I_{CQ} = \frac{V_{CC}}{N^2 R_L}}$$

$$\boxed{P_{L\,max} = \frac{V_{CC}^2}{2R'_L}}$$

$$\boxed{P_{C\,max} = V_{CC}\, I_{CQ}}$$



Espejo Corriente. - Polarización Balanceado.



$$\boxed{I_{CQ1} = I_{CQ2}\ (\text{Espejo})}$$

$$V_{CC} = R_B \cdot \left(I_{CQ} + \frac{2 I_{CQ}}{h_{fe}} \right) + V_{BE}$$

$$V_{CC} = R_B\, I_{CQ} \underbrace{\left(\frac{\beta + 2}{\beta} \right)}_{=1} + V_{BE}$$

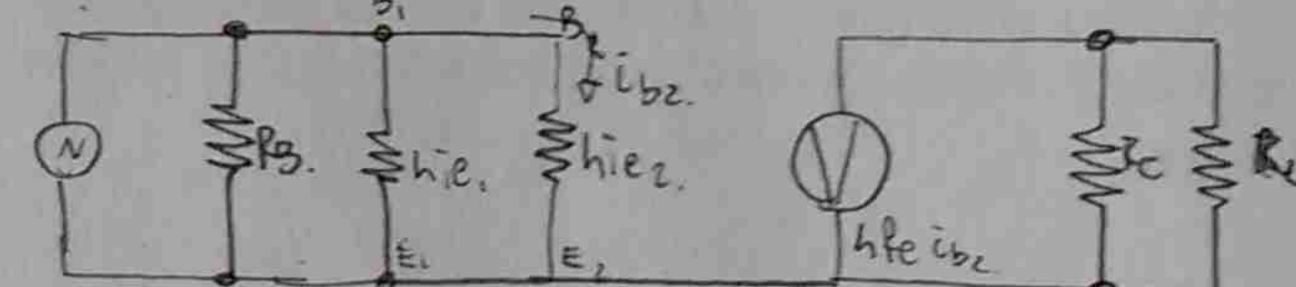
$$\boxed{I_{CQ} = \frac{V_{CC} - V_{BE}}{R_B}}$$

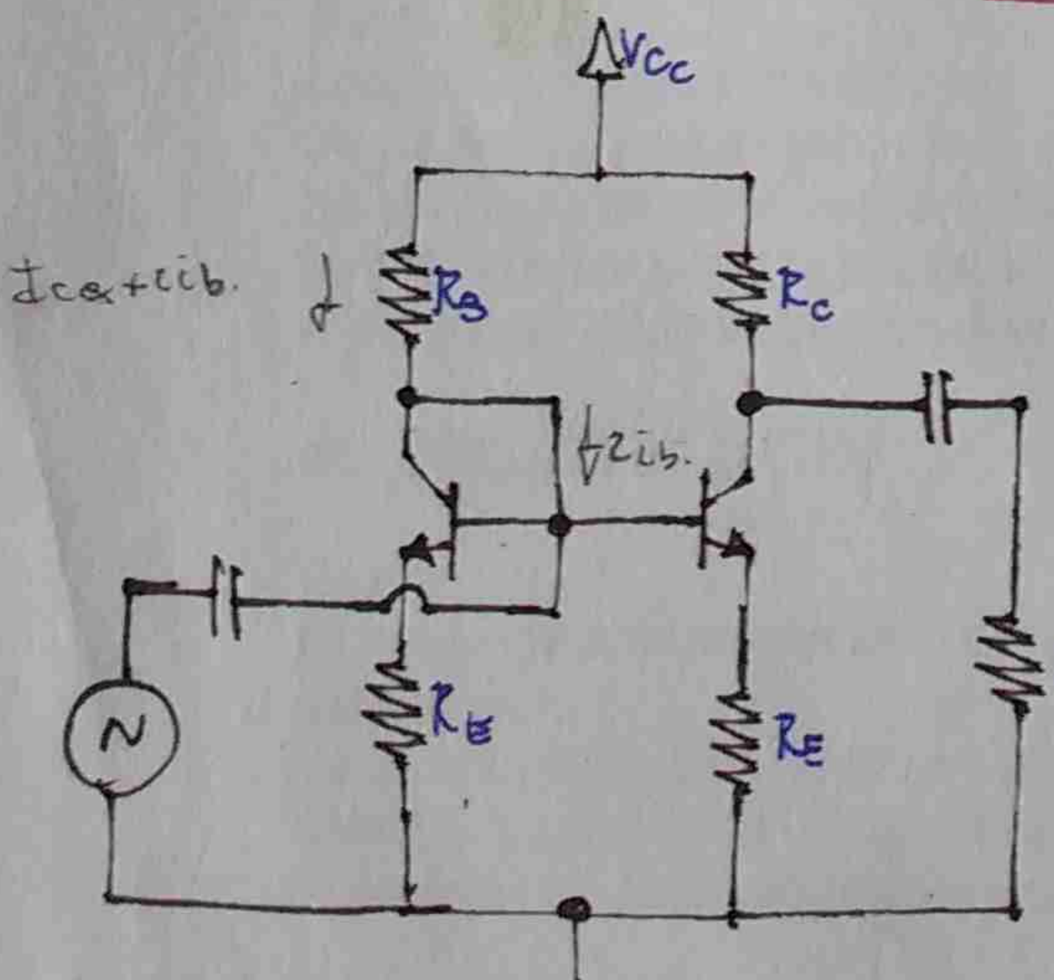
MES en el punto:

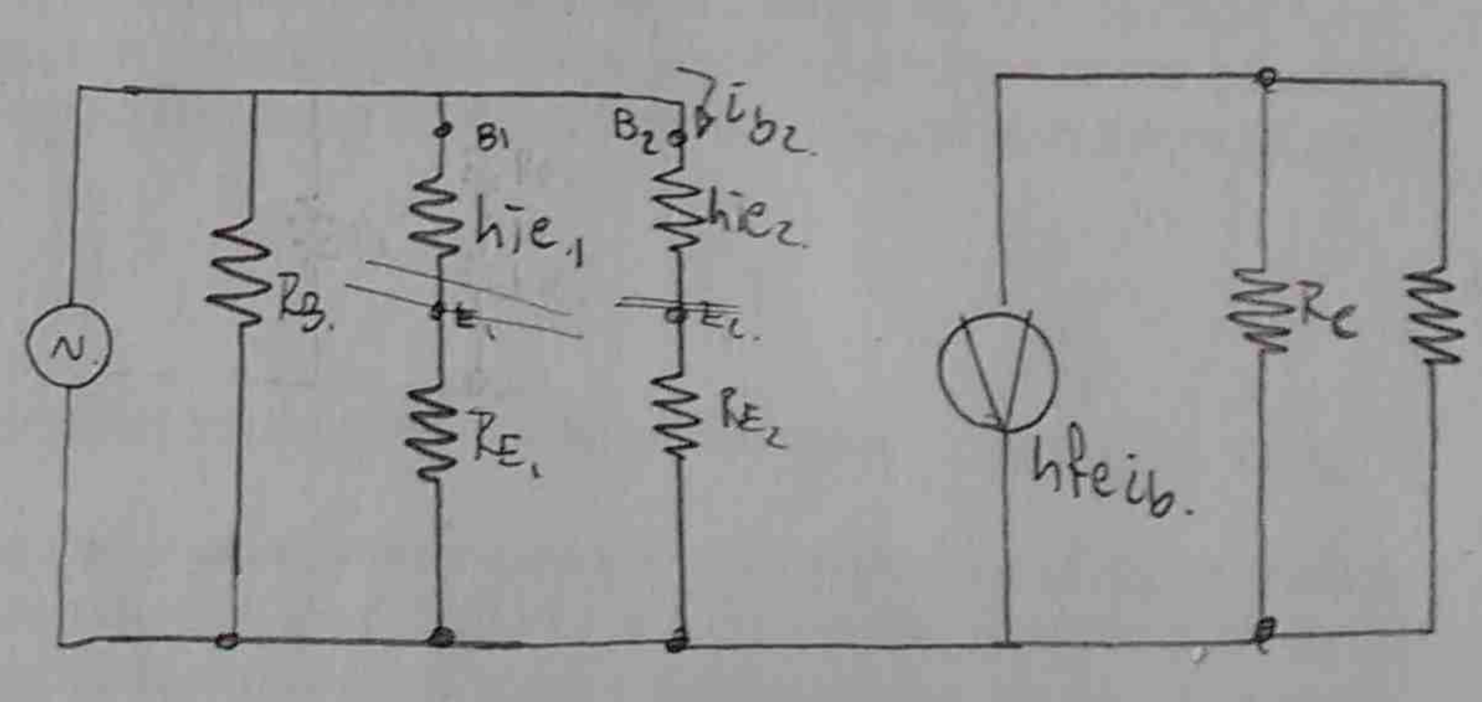
$$\boxed{I_{CQ\,MES} = \frac{V_{CC}}{R_{CC} + R_{CA}}}$$

$$\boxed{V_{CEQ\,MES} = V_{CC} - I_{CQ\,MES}\, R_C}$$

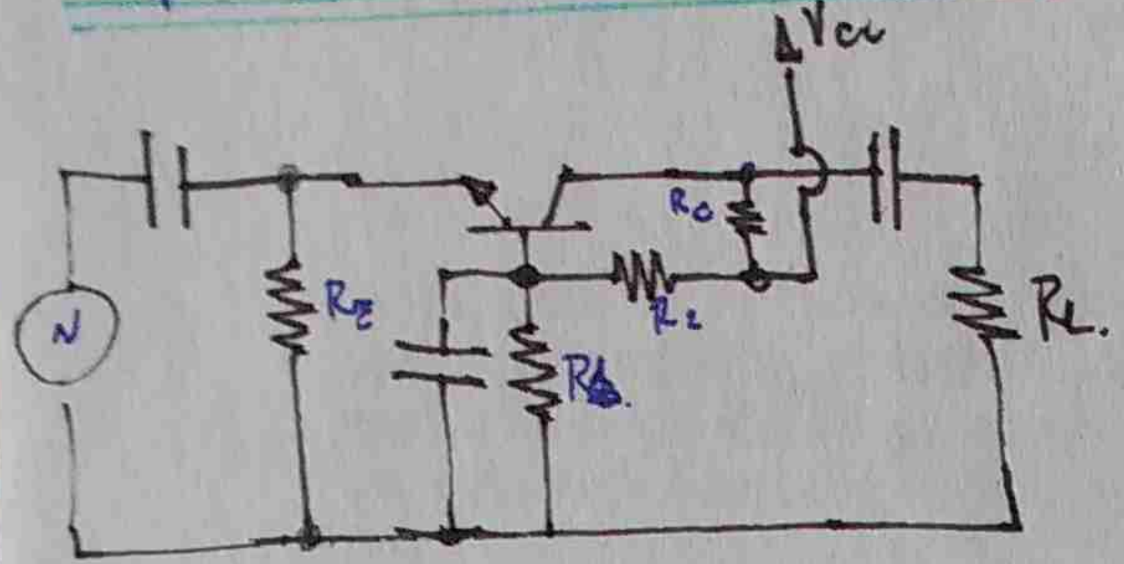
$$\boxed{R_{B\,MES} = \frac{V_{CC} - V_{BE}}{I_{CQ\,MES}}}$$



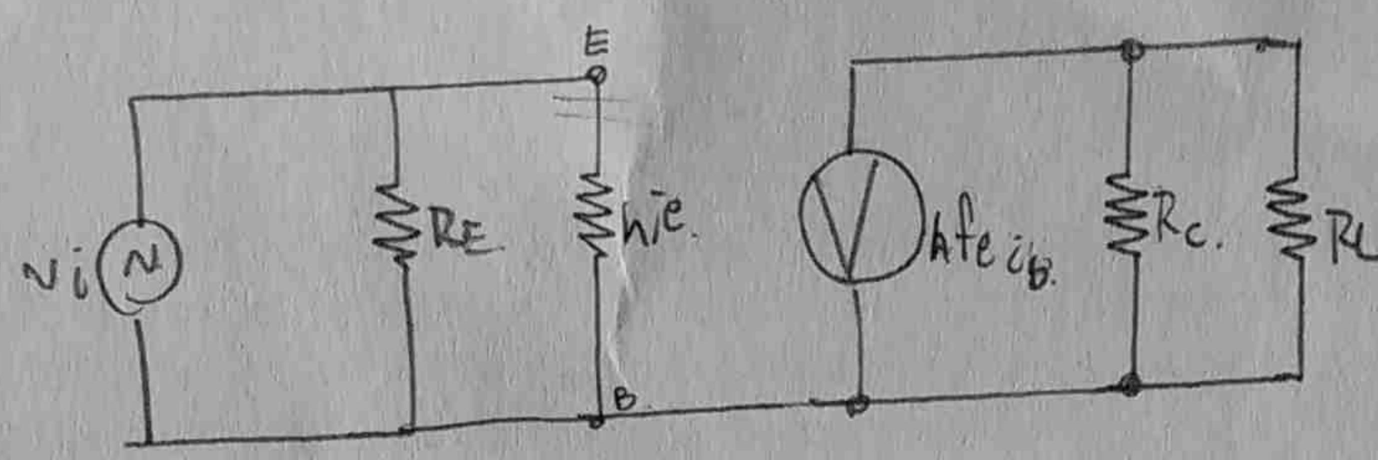




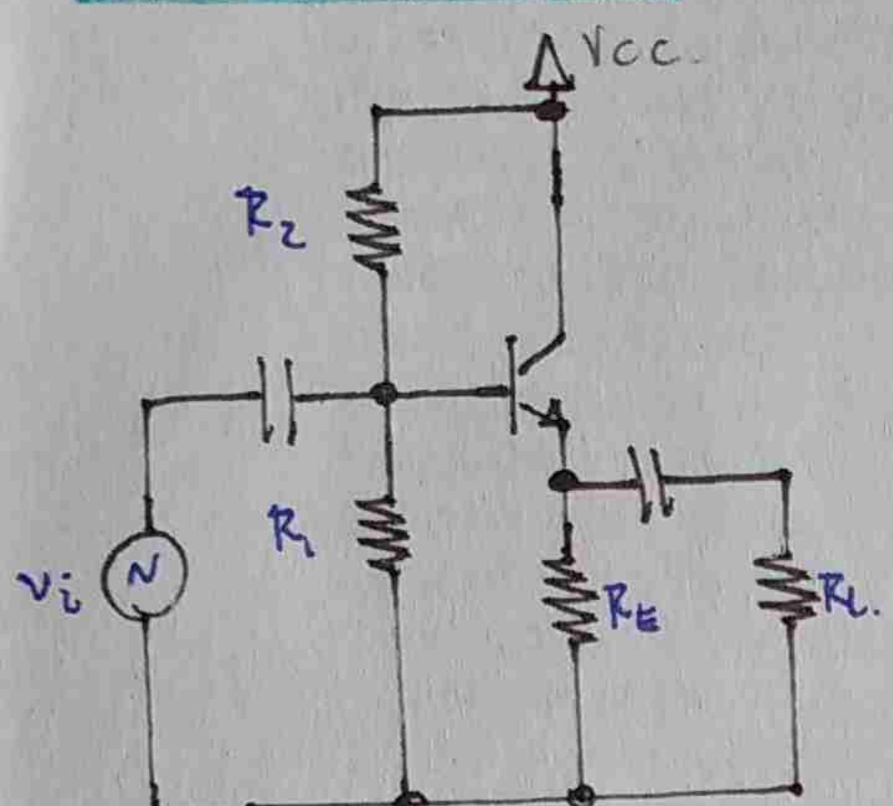
Amplificador Base común

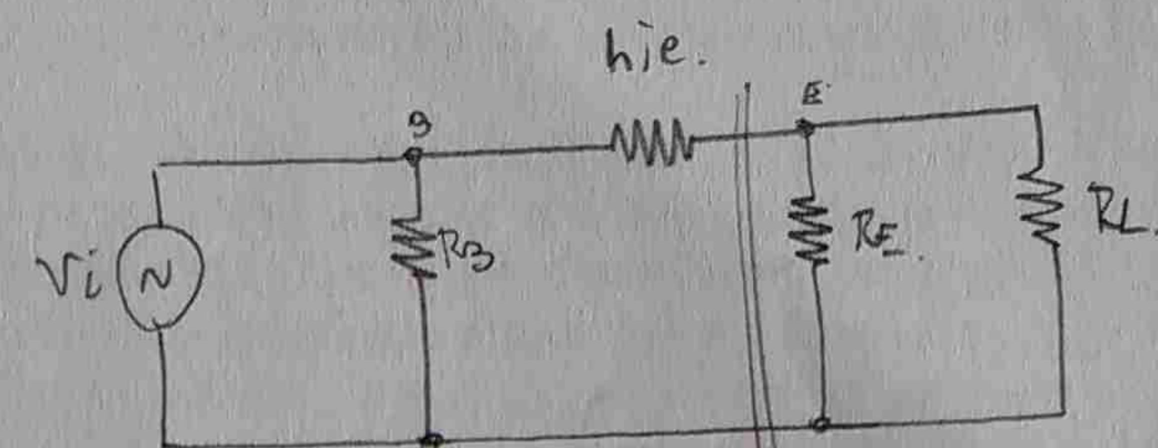


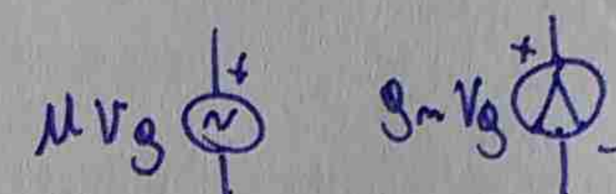
No se refleja.



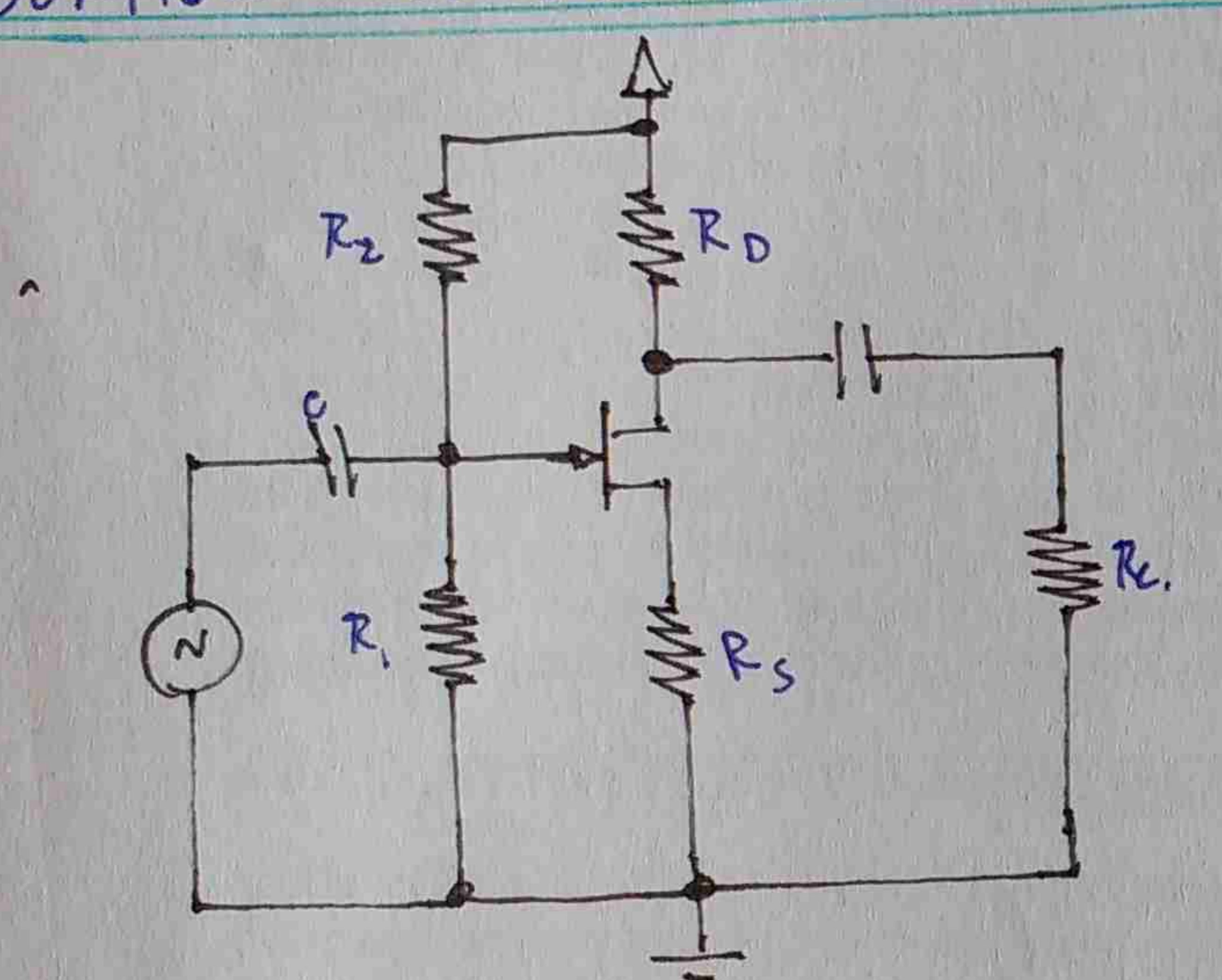
Colector Común

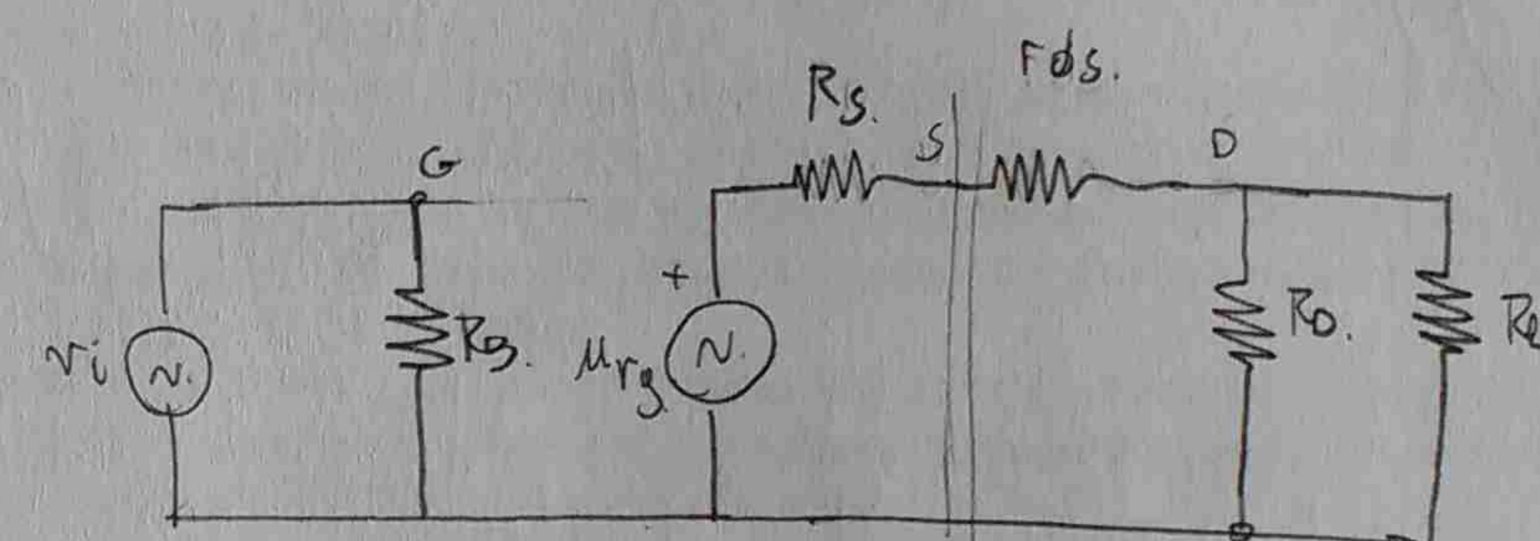






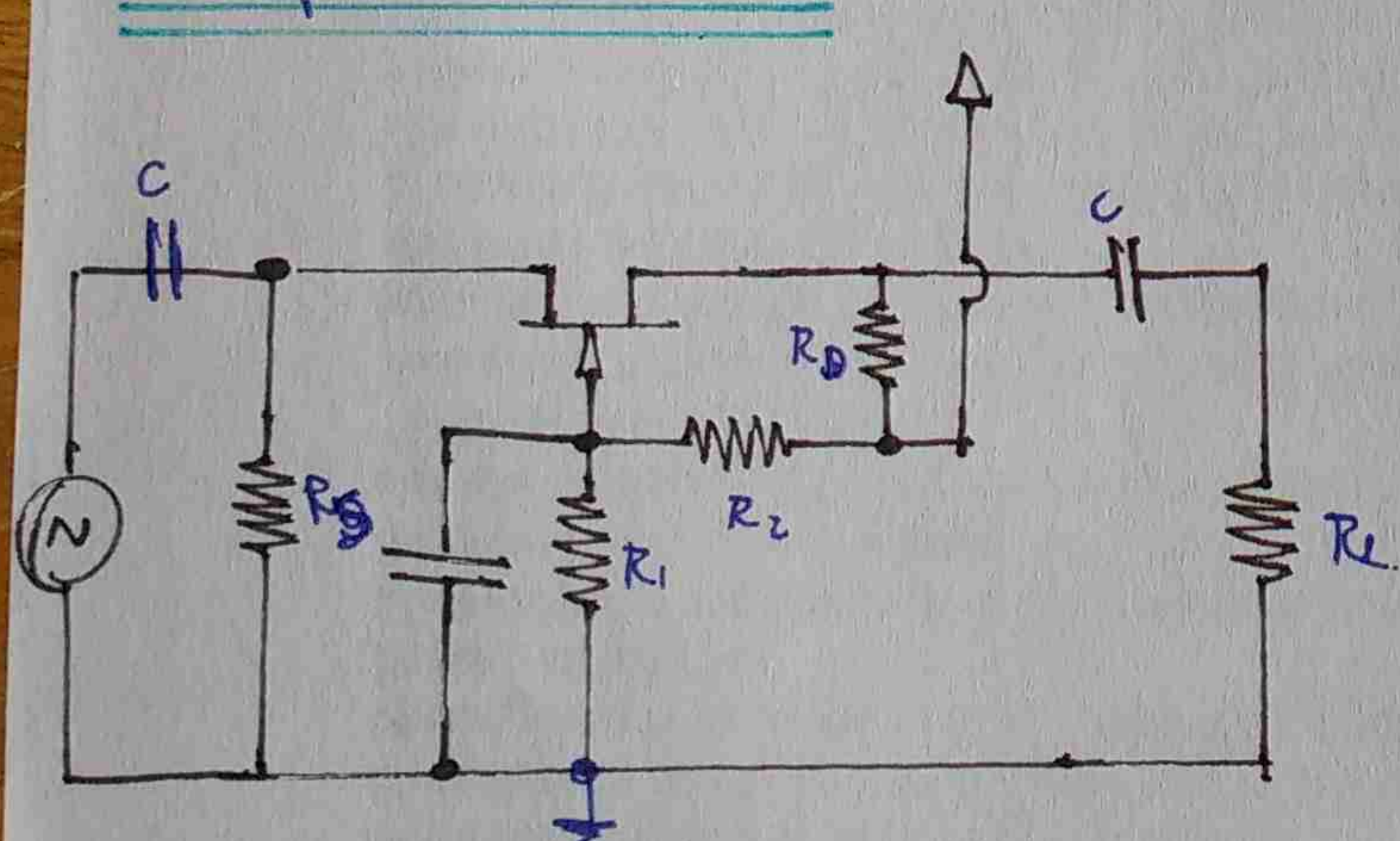
Surtidor común sin cap. de desacop.

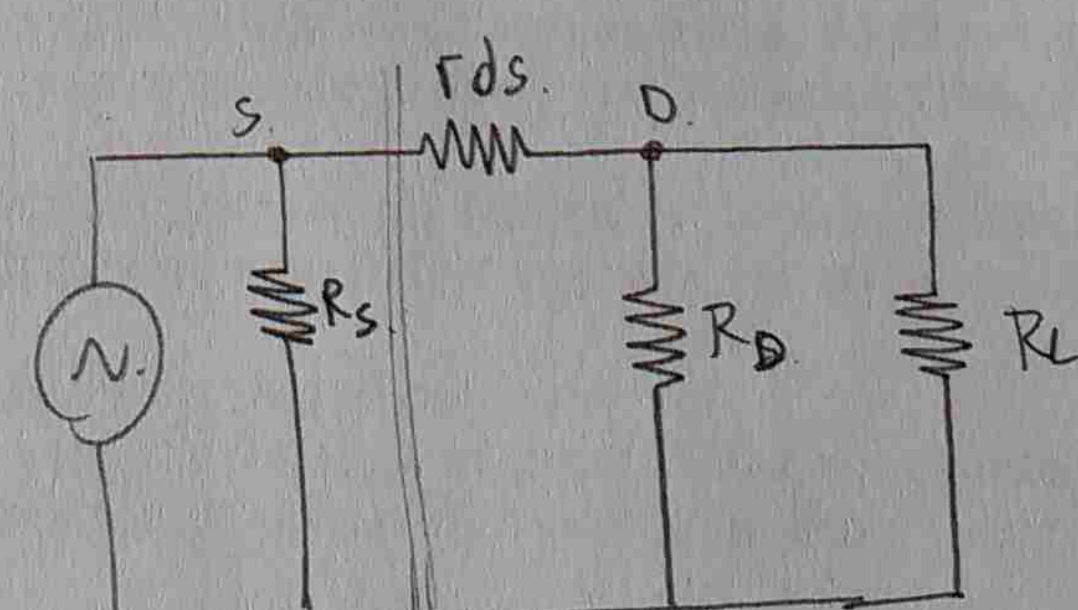




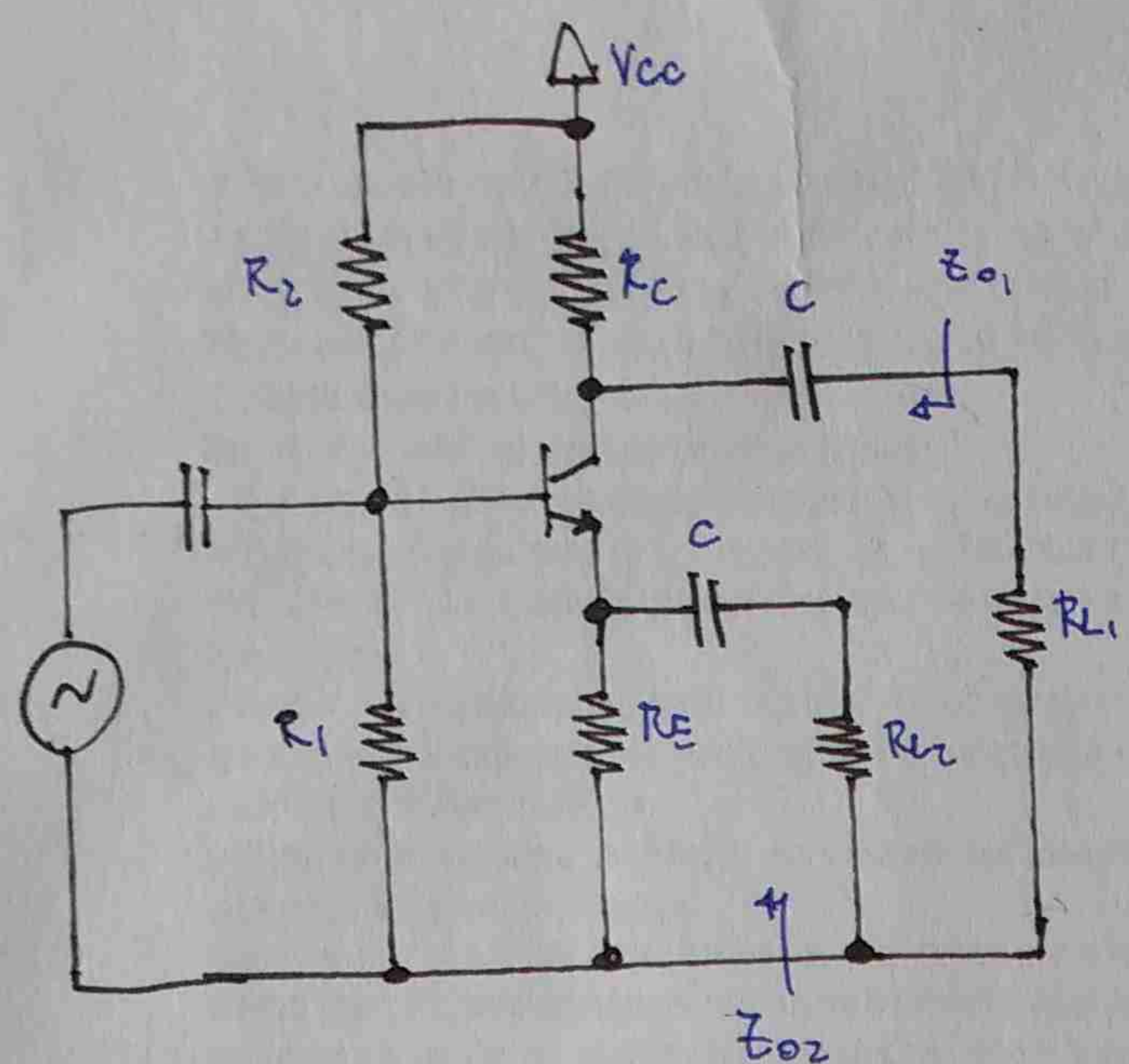
Surtidor —— Drenador. μ.

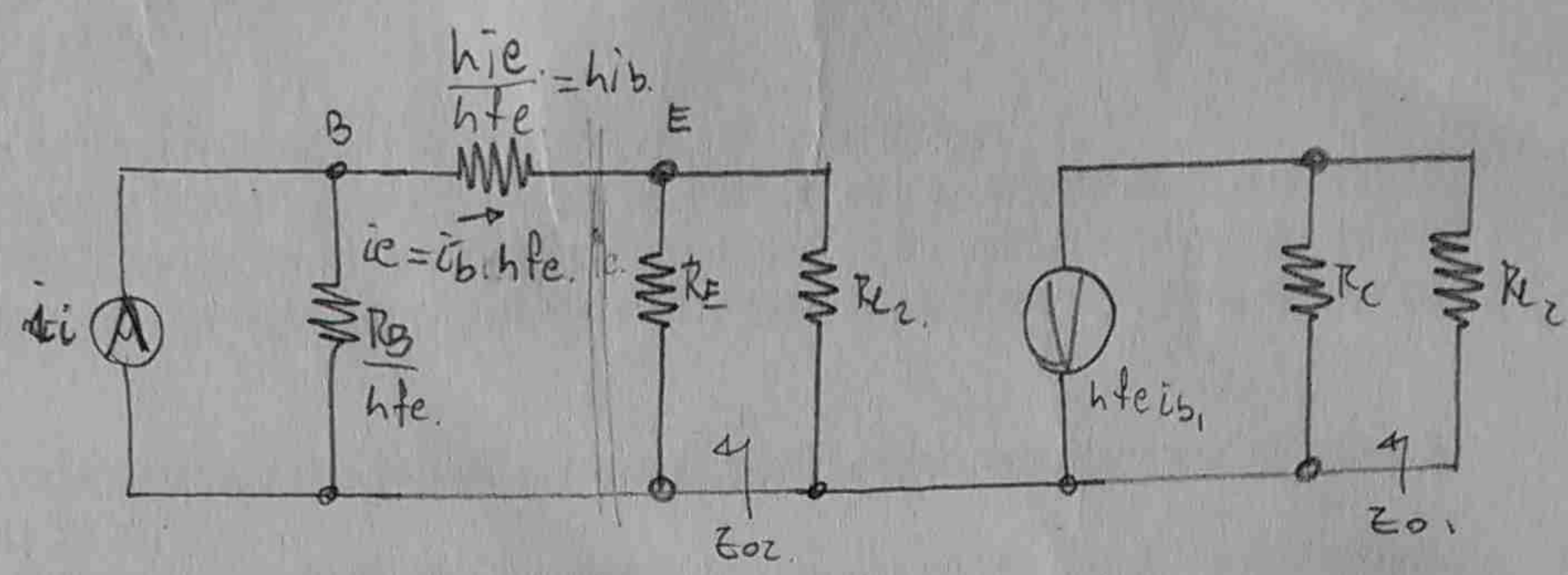
compuerta Común





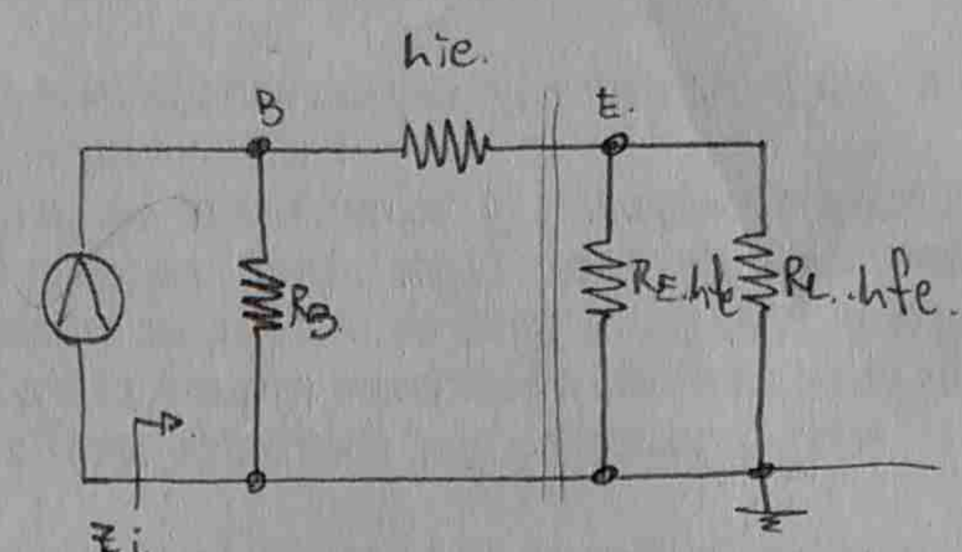
Inversor fase Bipolar



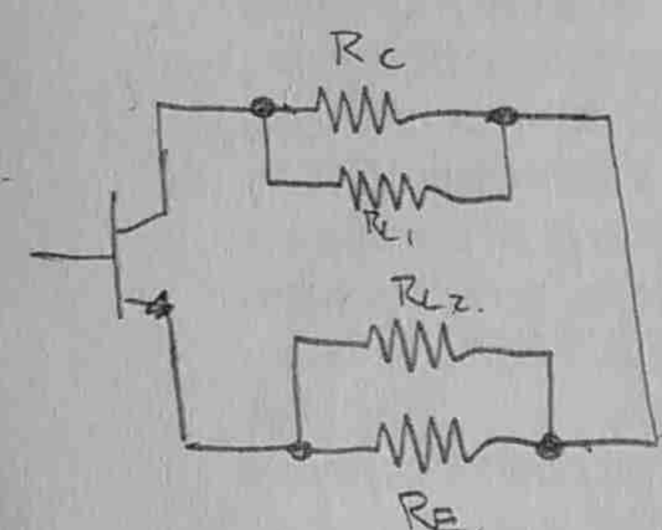


$$Z_{o2} = R_E \,//\, \left[h_{ib} + \frac{R_B}{h_{fe}}\right]$$

$$Z_{o1} = R_C$$



$$Z_i = R_B \,//\, \left[h_{ie} + (R_E // R_L)\, h_{fe}\right]$$

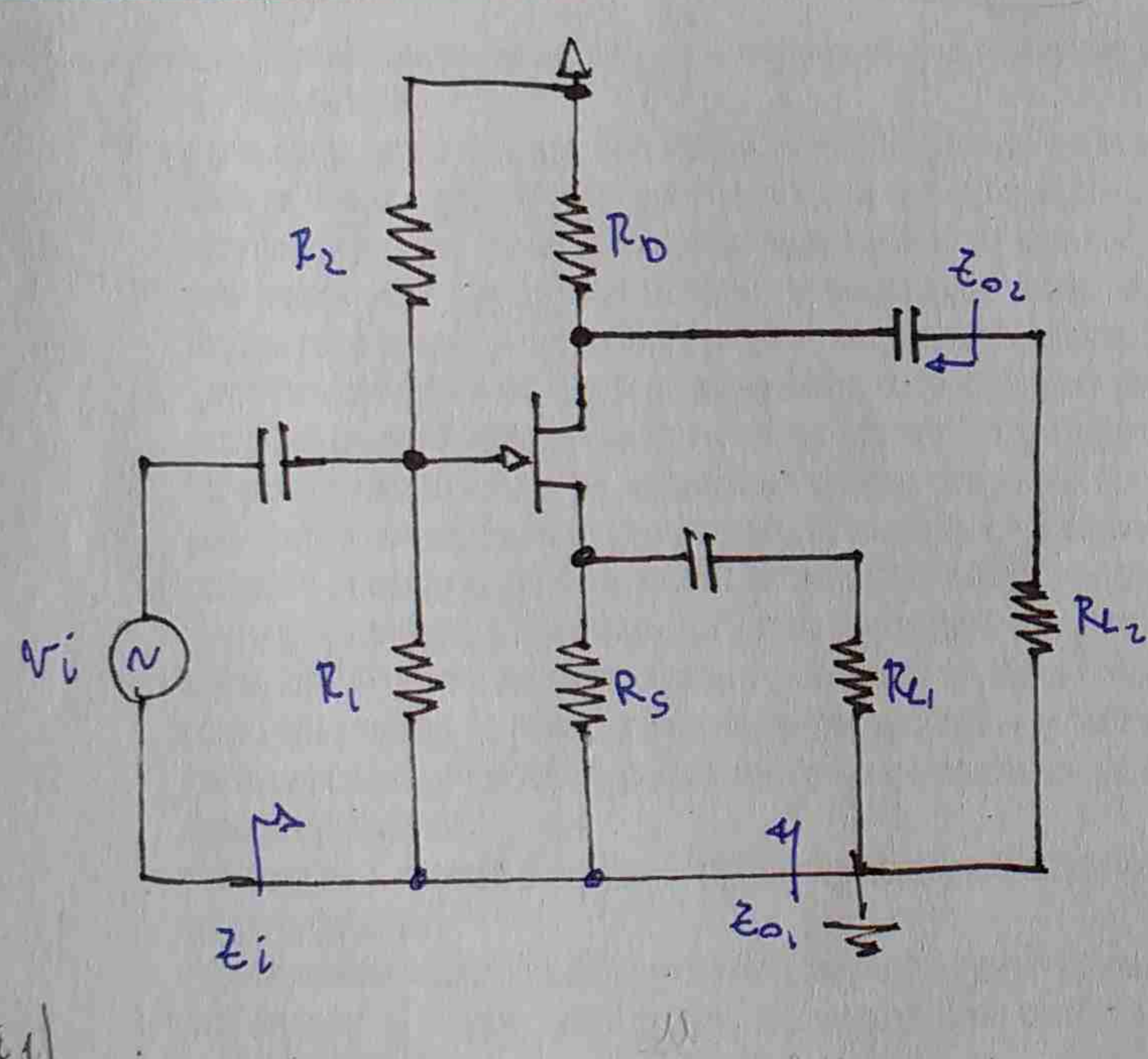


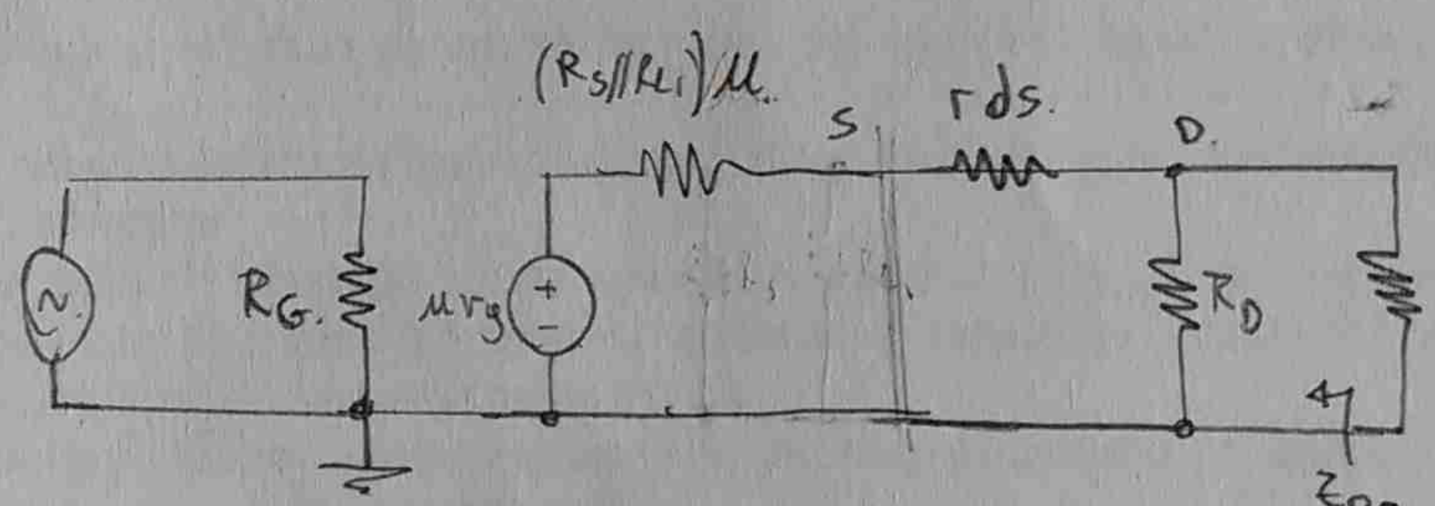
$R_{CA} = R_C // R_{L1} + R_E // R_{L2}$

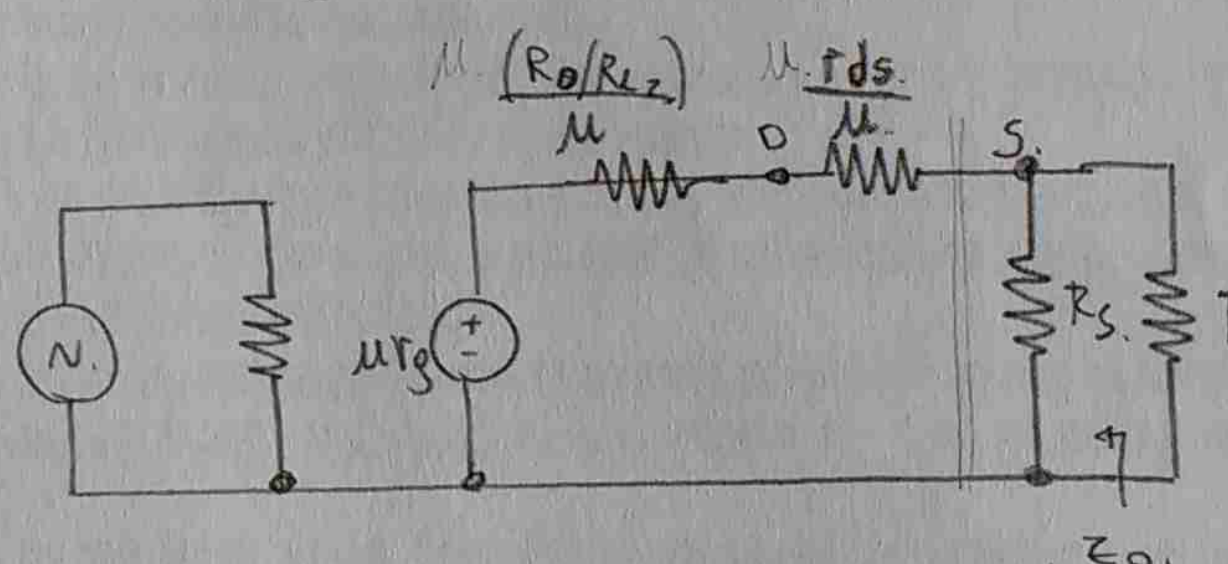
Inversor $R_C // R_{L1} = R_E // R_{L2}$

$R_{CA} = 2\,(R_C // R_{L1})$

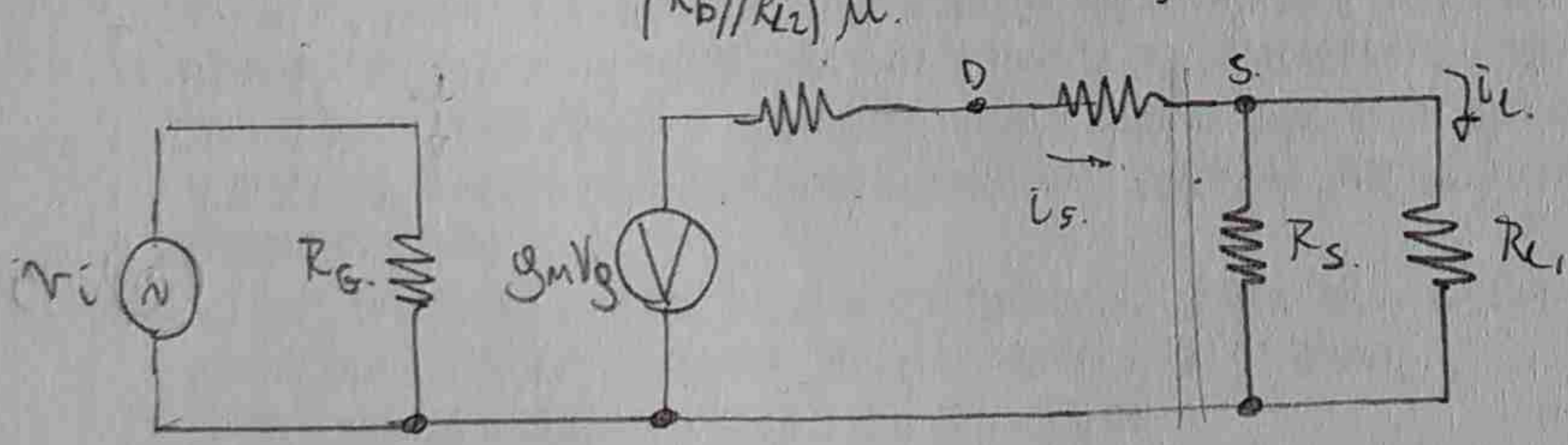
Inversor de fase JFET







$|A_{i1}|$



$$|A_{i1}| = \frac{i_L}{i_i} = \frac{i_L}{V_g} \cdot \frac{V_g}{i_i}$$

$$i_i = \frac{V_g}{R_g} \Rightarrow \frac{i_i}{V_g} = \frac{1}{R_g}$$

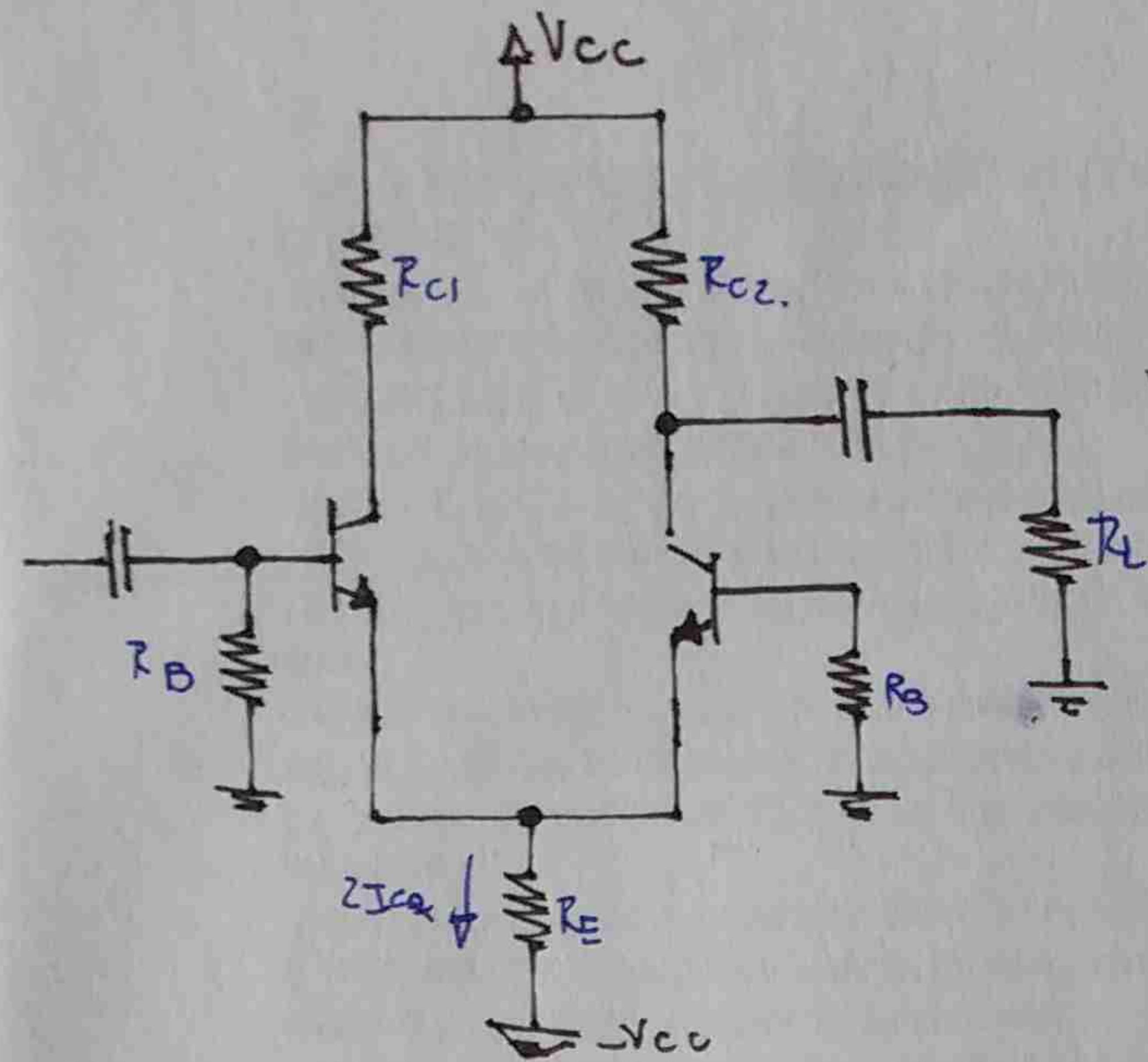
$$i_L = g_m V_g \cdot \frac{R_S}{R_S + R_{L1}} \Rightarrow \frac{i_L}{V_g} = g_m \cdot \frac{R_S}{R_S + R_{L1}}$$

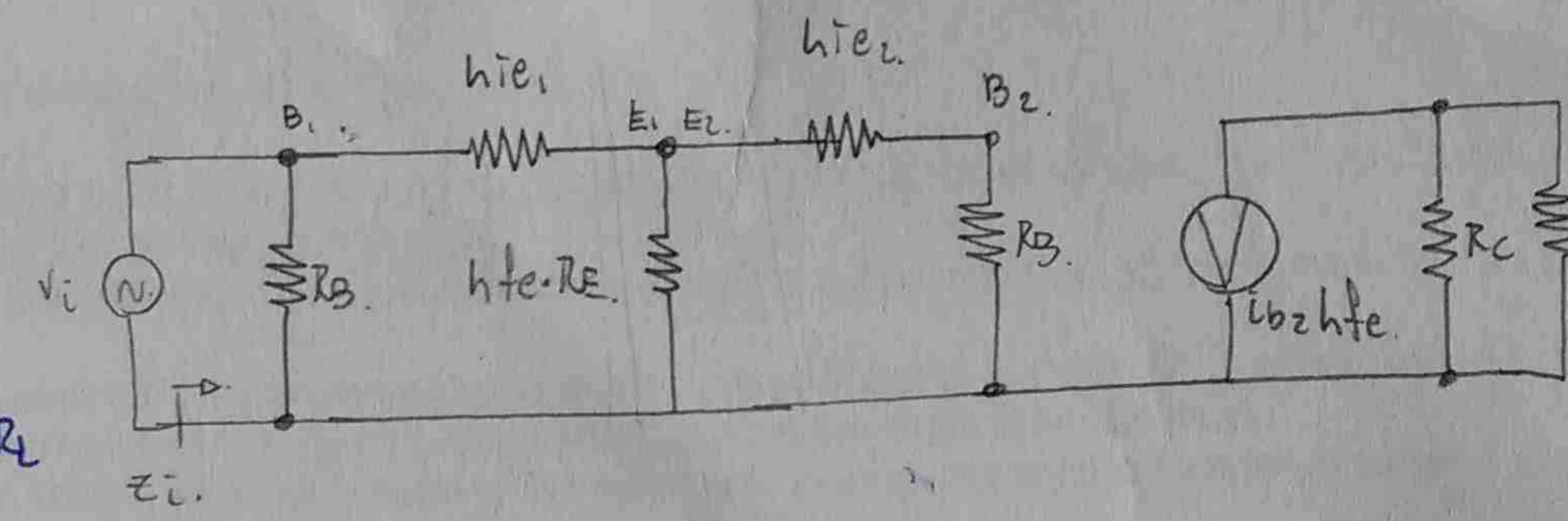
$$|A_{i1}| = \frac{1}{R_g}\, g_m \frac{R_S}{R_S + R_{L1}}$$

$$\left.\begin{aligned} A_{i1} &= A_v \cdot \frac{Z_i}{R_{L1}} \\ A_{i2} &= A_v \cdot \frac{Z_i}{R_{L2}} \end{aligned}\right\} R_{L1} \neq R_{L2}$$ No Tienen igual ganancia de I

Amplificador diferencial. (Asimétrico)

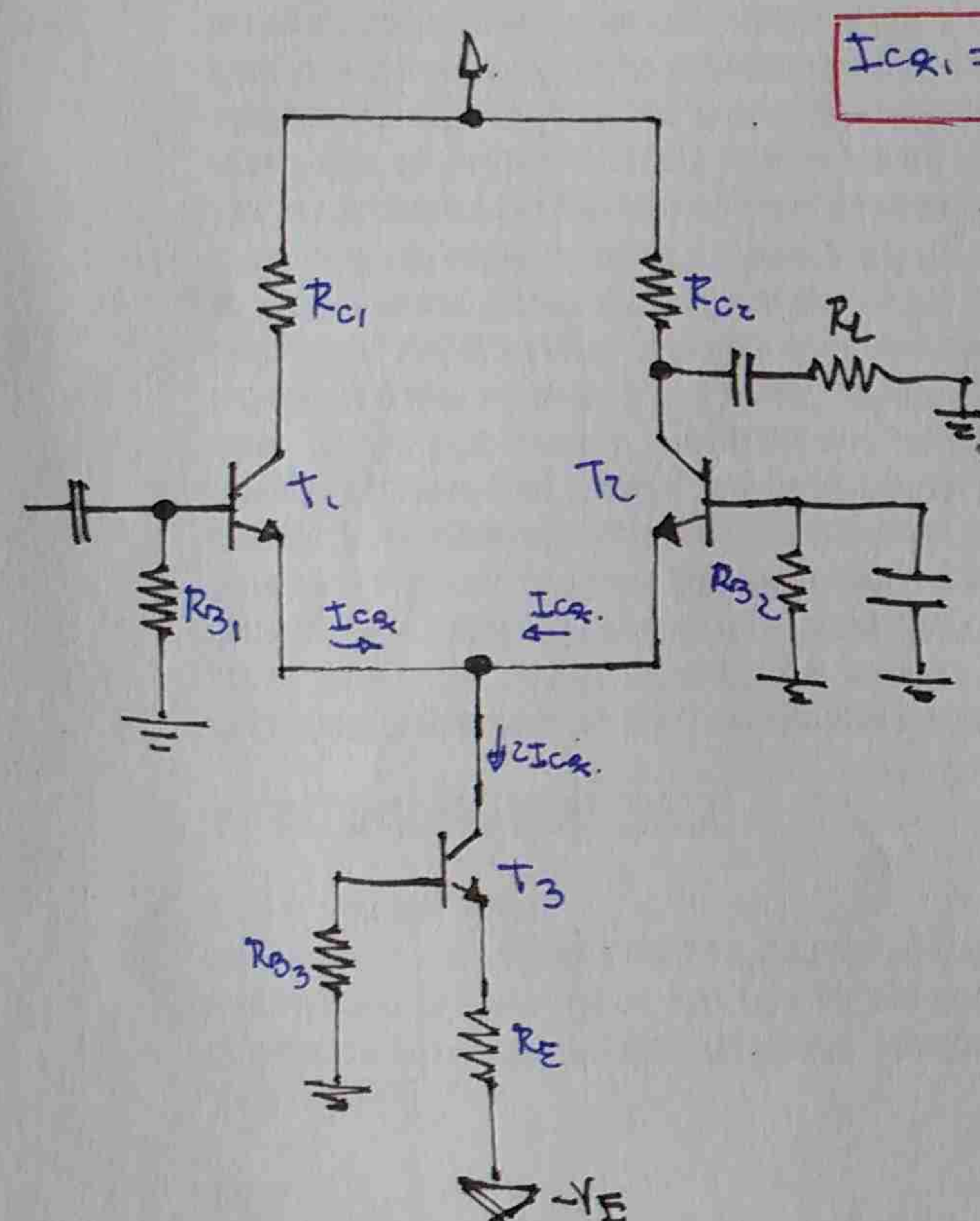
$$\boxed{I_{CQ1} = I_{CQ2}}$$

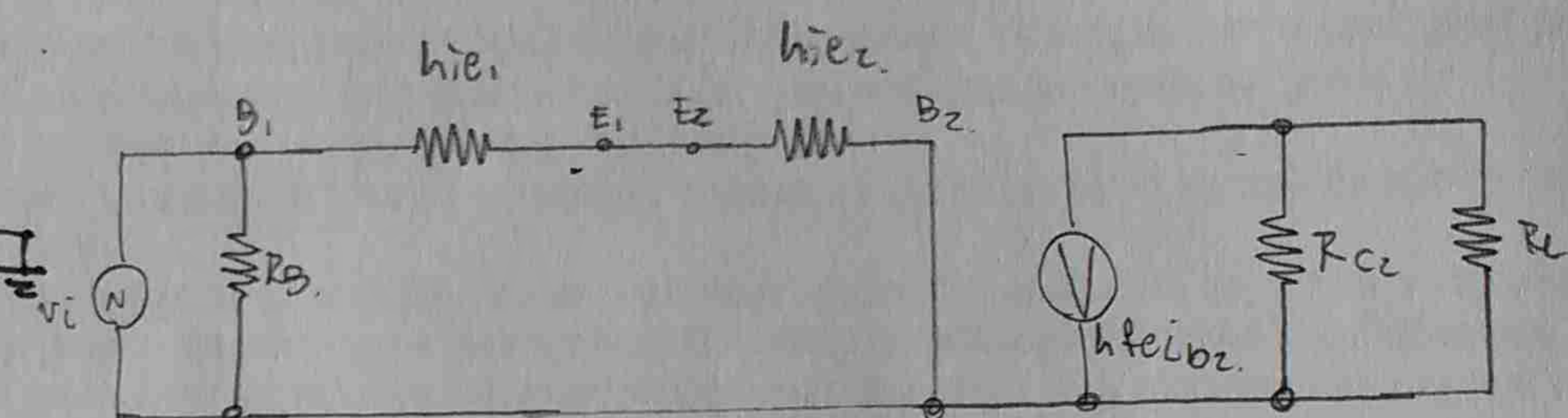


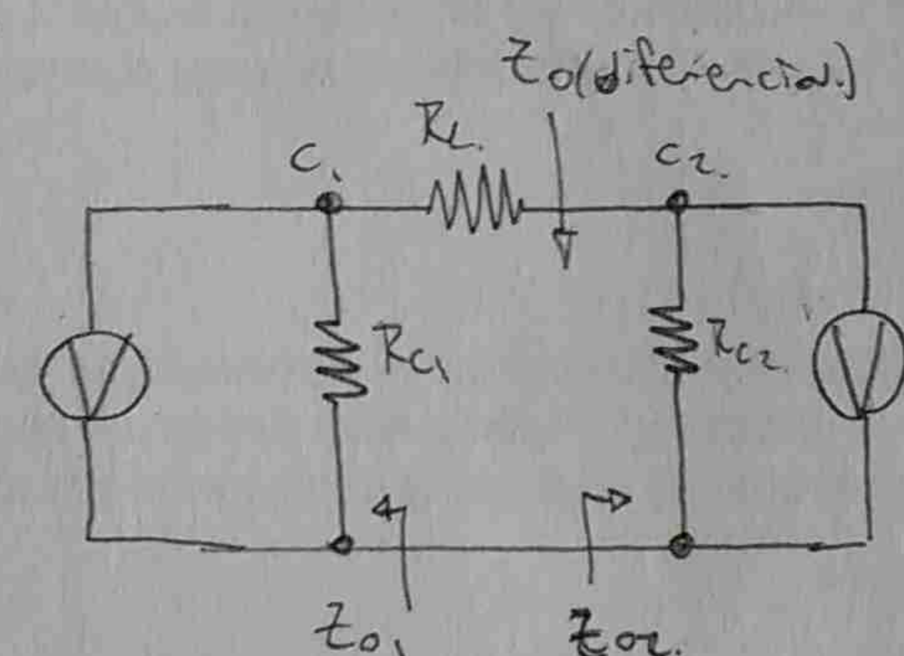


Ampl. Con 3° Transistor

$$\boxed{I_{CQ1} = I_{CQ2} = \frac{I_{CQ3}}{2}}$$

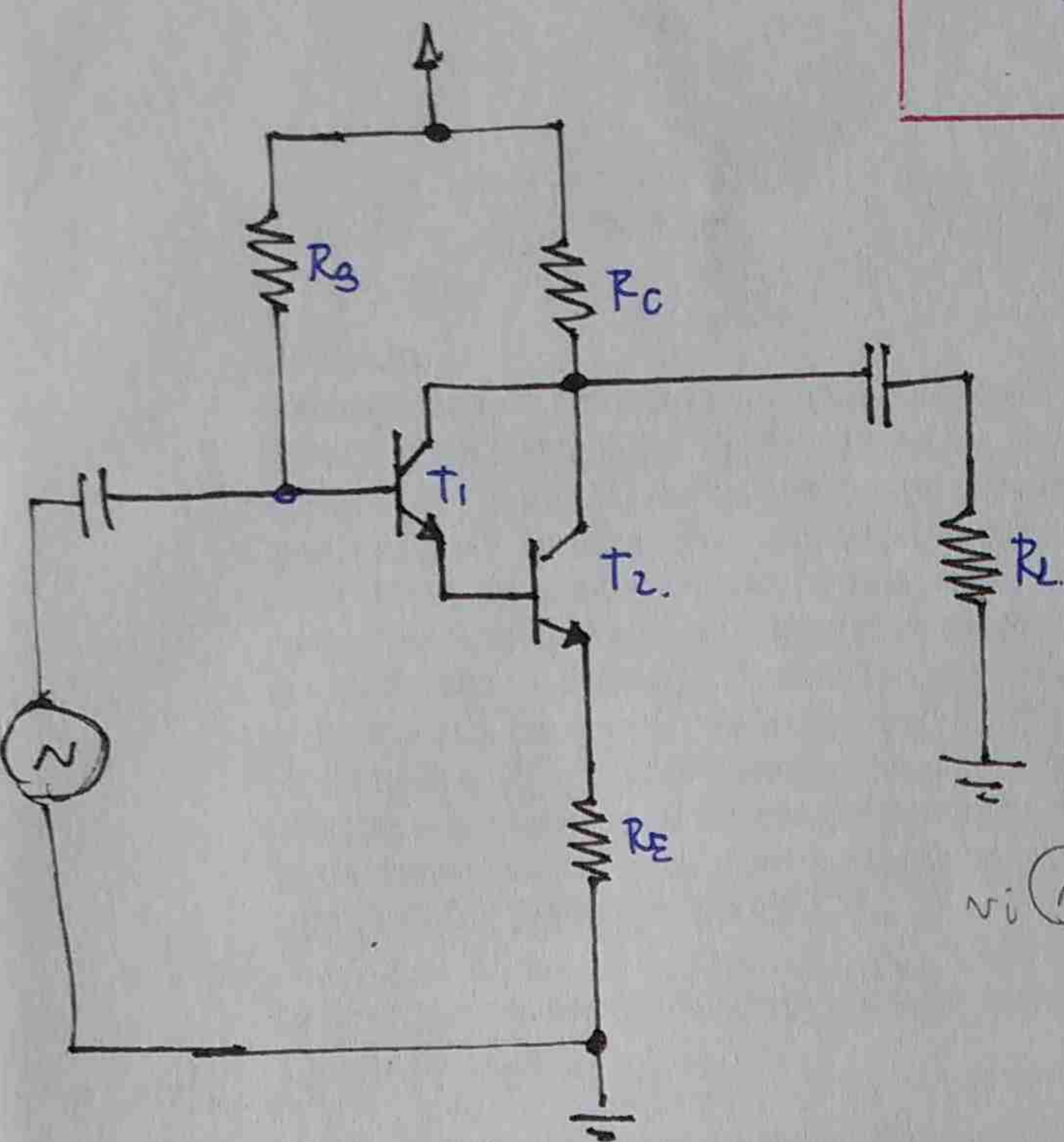






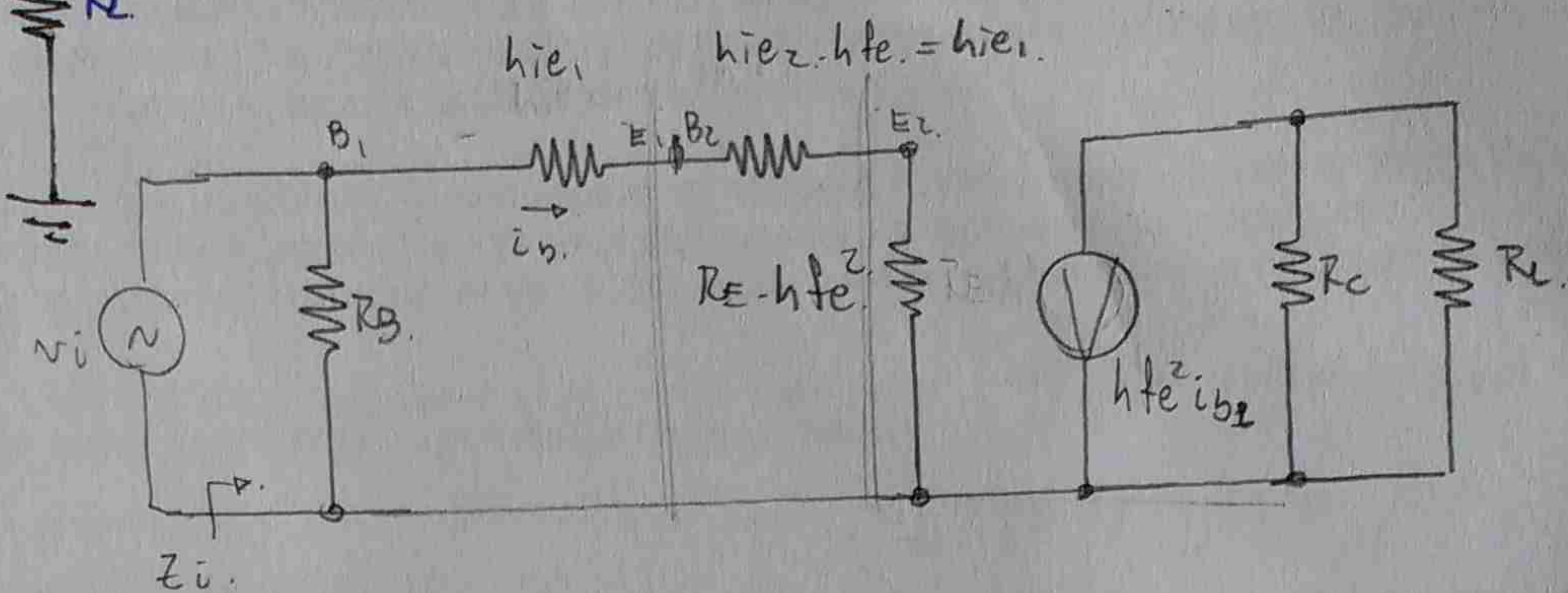
Par Darlington

$$\boxed{\eta_{max} = \frac{P_{L\_max}}{P_{cc\_max}}}$$

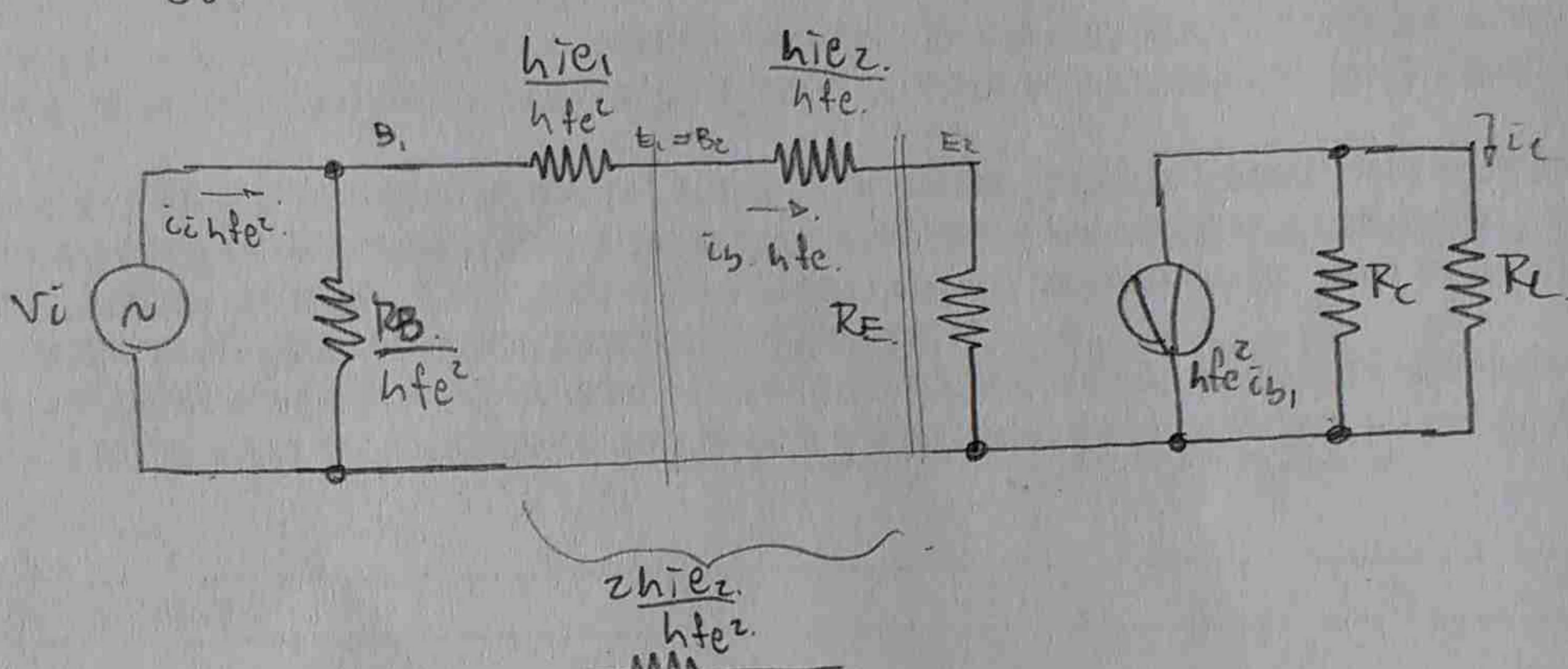


$$\boxed{P_{L\_max} = \frac{1}{2}\left(\frac{I_{c\,max}}{2}\right)^2 R_L}$$

$$\boxed{P_{cc} = V_{cc} \cdot I_{c\,max}}$$



A_i



$$\Delta I_{CQ} = S_V \, \Delta V_{BE} + S_I \, \Delta I_{CBO} + S_\beta \, \Delta \beta$$

$$S_V = -\frac{1}{R_E} = \frac{\partial I_{CQ}}{\partial V_{BE}}$$

$$S_I = 1 + \frac{R_B}{R_E} = \frac{\partial I_{CQ}}{\partial I_{CBO}}$$

$$S_\beta = \frac{I_{CQ}}{\beta_1} \; \frac{R_B + R_E}{R_B + (\beta_2 + 1) R_E}$$

La polarización balanceada se utiliza cuando necesitamos mucha estabilidad a cambios de ΔT altos. Normalmente se aumentaría R_E, pero esto disminuye la I_{CQ}, perdiendo ganancia.

__Amplificador cascode.__ Para evitar la disminución del ancho de banda debido a la realimentación por el capacitor interelectródico

Baja impedancia de entrada.

= EC = | BC =

__Rendimiento__ (Mayor Posible)

$$\boxed{\eta = \frac{P_L}{P_{cc}}}$$

__FM__ (Menor Posible)

$$\boxed{FM = \frac{P_{C\,max}}{P_{L\,max}}}$$

$P_{C\,max}$ ← Máxima potencia en el colector

$P_{L\,max}$ ← Max pot en la carga.

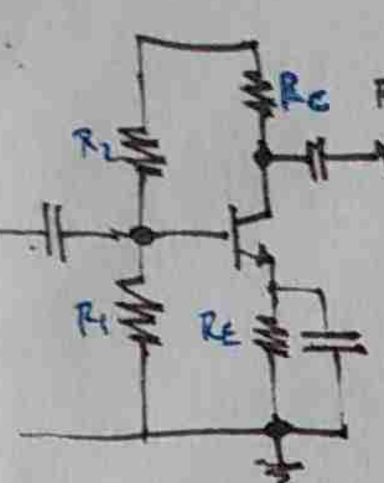
$$P_C = \frac{V_{CC}^2}{2R_L} - \frac{V_{CC}^2}{4R_L} - \underbrace{\frac{V_{CC}^2}{8R_L}}_{\text{Señal CA.}}$$

$P_{C\,max}$ (sin señal) $= \dfrac{V_{CC}^2}{4R_L}$

$P_{C\,min}$ (señal max) $= \dfrac{V_{CC}^2}{8R_L}$

Sin inductor	Con inductor.
FM = 2.	
$\eta = 0{,}25$	$\eta = 0{,}5$

Emisor Co-un Cap desacople.

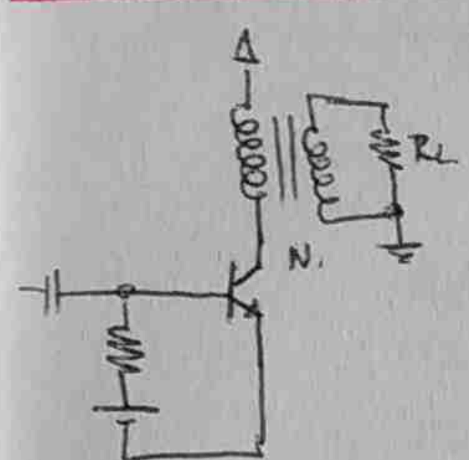


$$P_{L\,max} = \frac{I_{cq}^2}{8} R_L$$

$$P_{cc\,max} = V_{cc} I_{cq}$$

$$\hat{i}_{L\,max} = \frac{i_{c\,max}}{2} = \frac{I_{cq}}{2}$$

Clase A Trafo

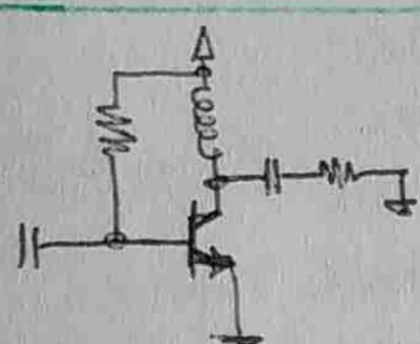


$$R'_L = N^2 R_L$$

$$P_{L\,max} = \frac{V_{cc}^2}{2R'_L}$$

$$P_{cc\,max} = V_{cc} I_{cq}$$

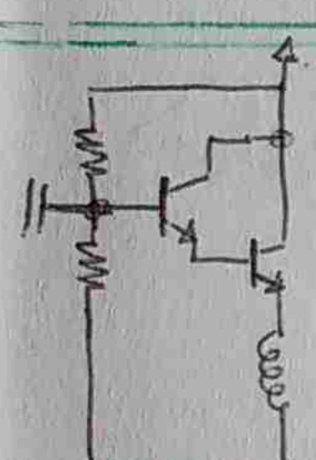
$$I_{cq} = \frac{V_{cc}}{N^2 R_L}$$



$$FM = 2 = \frac{P_{c\,max}}{P_{L\,max}}$$

$$\frac{V_{cc}^2}{2R_L} = \frac{P_{c\,max}}{2} \Rightarrow P_{c\,max} = \frac{V_{cc}^2}{R_L}$$

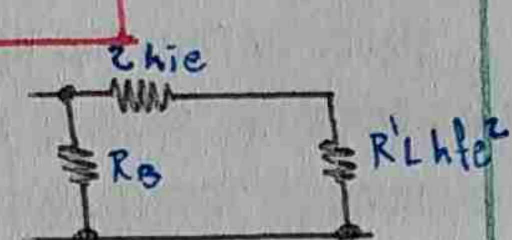
$$I_{cq} = \frac{V_{cc}}{R_L}$$



$$V_{BB} = R_B \frac{I_{cq}}{h_{fe}^2} + 2V_{BE}$$

$$V_{CEq2} = V_{cc}$$

$$V_{CEq1} = V_{CEq2} - V_{BE}$$



espejo

$$I_{cq1} = I_{cq2}$$

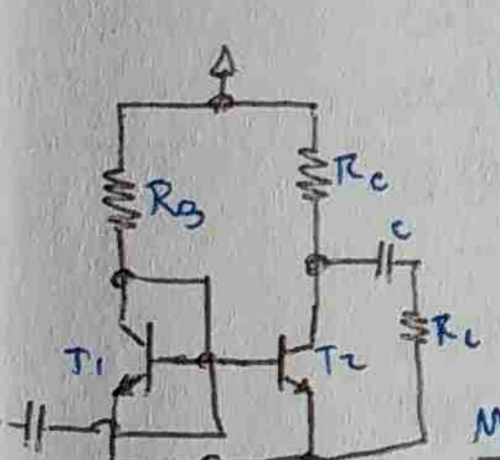
$$I_{cq2} = \frac{V_{cc} - V_{BE}}{R_B}$$

$$V_{CEq1} = 0{,}7V$$

diodo

$$\cancel{V_{CEq2} = V_{cc} - I_{cq2} R_c}$$

$$\frac{\beta + 2}{\beta} = 1$$



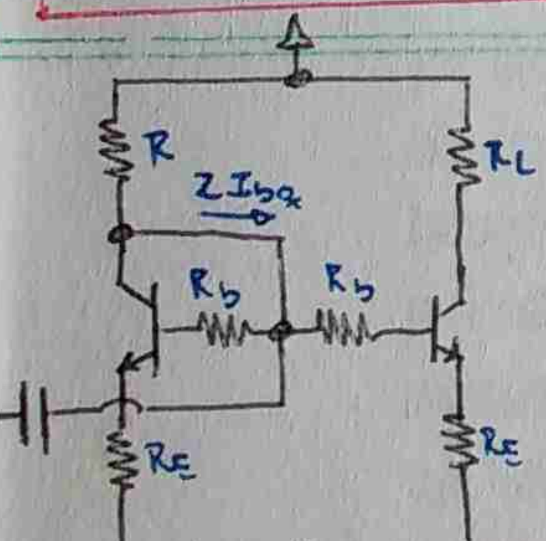
MES En el punto

$$I_{cq\,MES} = \frac{V_{cc}}{R_{cc} + R_{ca}}$$

$$V_{CEq\,MES} = V_{cc} - I_{cqm} R_c$$

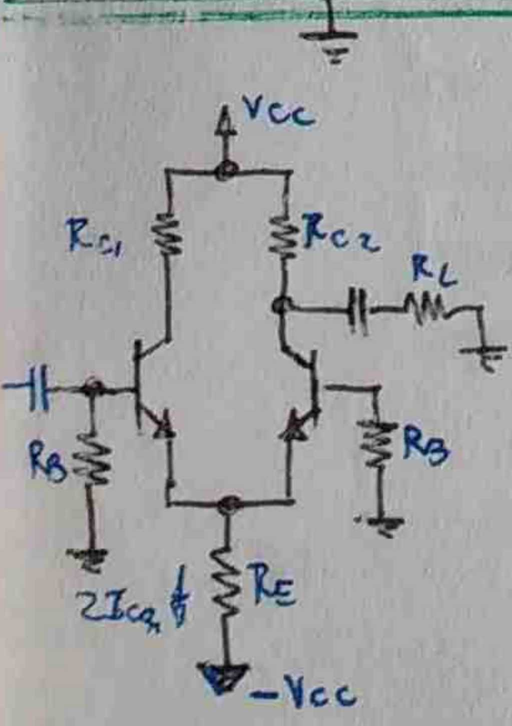
$$R_{B\,MES} = \frac{V_{cc} - V_{BE}}{I_{cqm}}$$

$$\Delta I_{cq} = \frac{K \Delta T}{R_B}$$



$$V_{cc} = \left(\frac{2I_{cq}}{h_{fe}} + I_{cq}\right) R + \frac{I_{cq}}{h_{fe}} R_b + V_{BE} + R_E I_{cq}$$

$$V_{CEq2} = V_{cc} - I_{cq}(R_L + R_E)$$

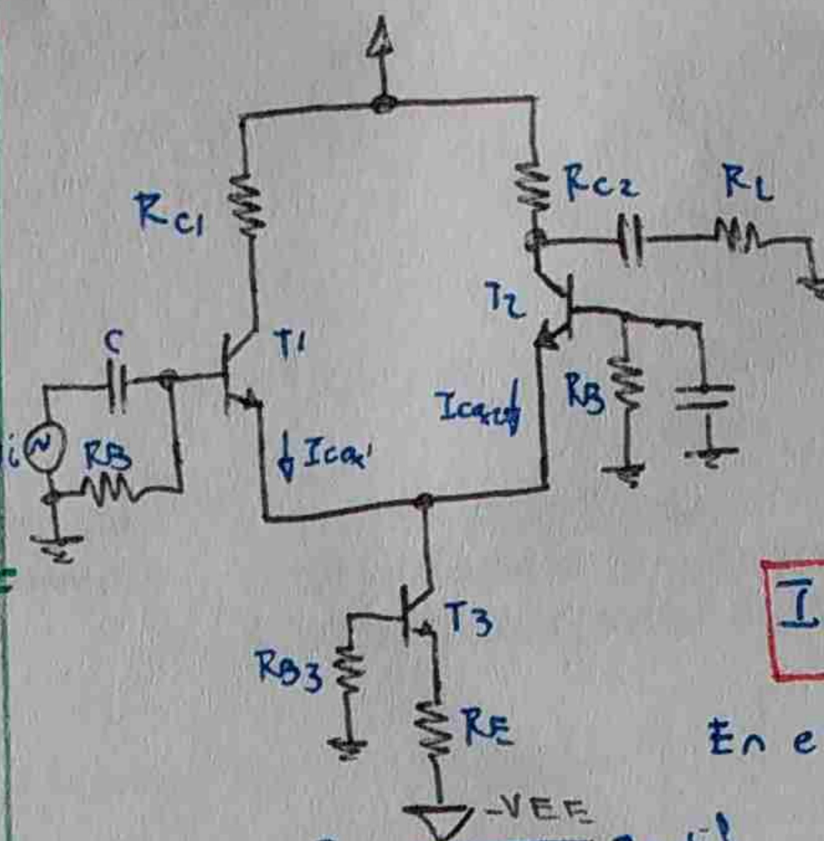


$$I_{cq1} = I_{cq2}$$

$$V_{cc} = \frac{I_{cq}}{h_{fe}} R_{B2} + V_{BE} + 2 I_{cq} R_E$$

$$V_{CEq1} = V_{cc} - I_{cq}(R_{c1} + 2R_E)$$

$$I_{cq} = \frac{V_{EE} - V_{BE}}{\frac{R_B}{\beta} + 2R_E}$$



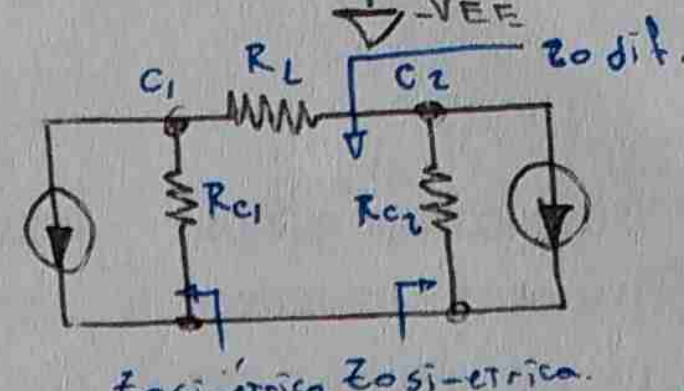
$$2V_{cc} = I_{cq1} R_{c1} + V_{CEq1} + V_{CEq3} + I_{cq3} R_E$$

$$2V_{cc} = I_{cq2} R_{c2} + V_{CEq2} + V_{CEq3} + I_{cq3} R_E$$

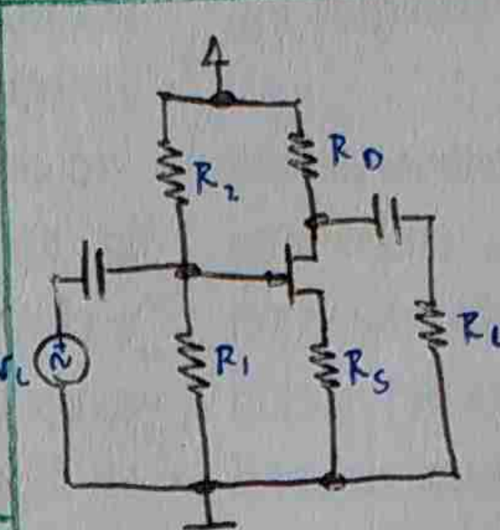
$$V_{cc} = \frac{I_{cq2}}{h_{fe}} R_B + V_{BE} + V_{CEq3} + R_E I_{cq3}$$

$$I_{cq1} = I_{cq2} = \frac{I_{cq3}}{2}$$

En el circ. equiv. C pone a masa a B2



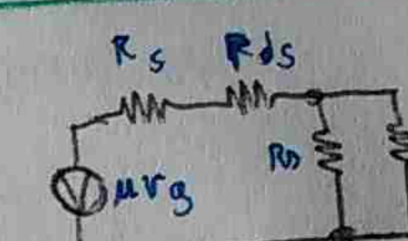
Para MES

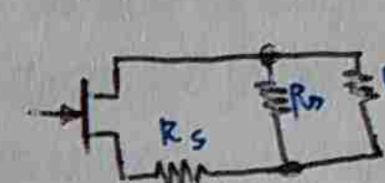


$$\frac{\mu}{r_{ds}} = g_m$$

$$\hat{i}_{o\,max} = I_{Dq}$$

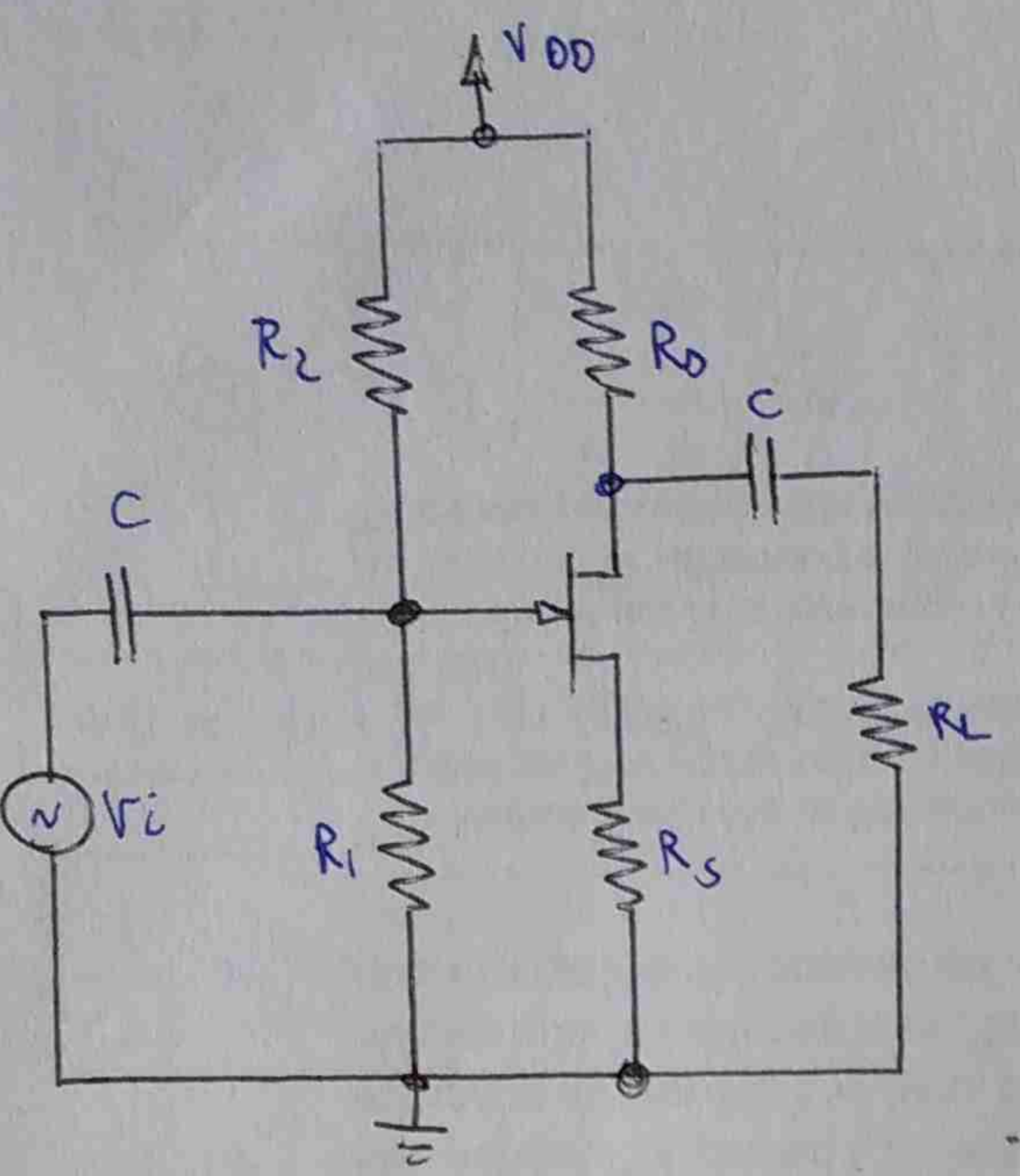
$$\hat{v}_{DS} = V_{DSq}$$

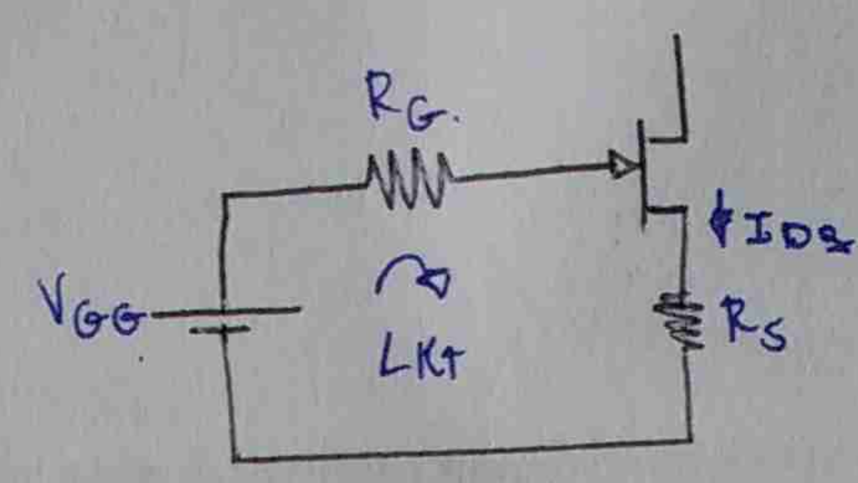




$$V_{DSq} = I_{Dq}(R_S + R_D // R_L)$$

Surtidor común sin cap de desacopl





$$\boxed{V_{GG} = \frac{V_{DD}}{R_1 + R} \cdot R_1}$$

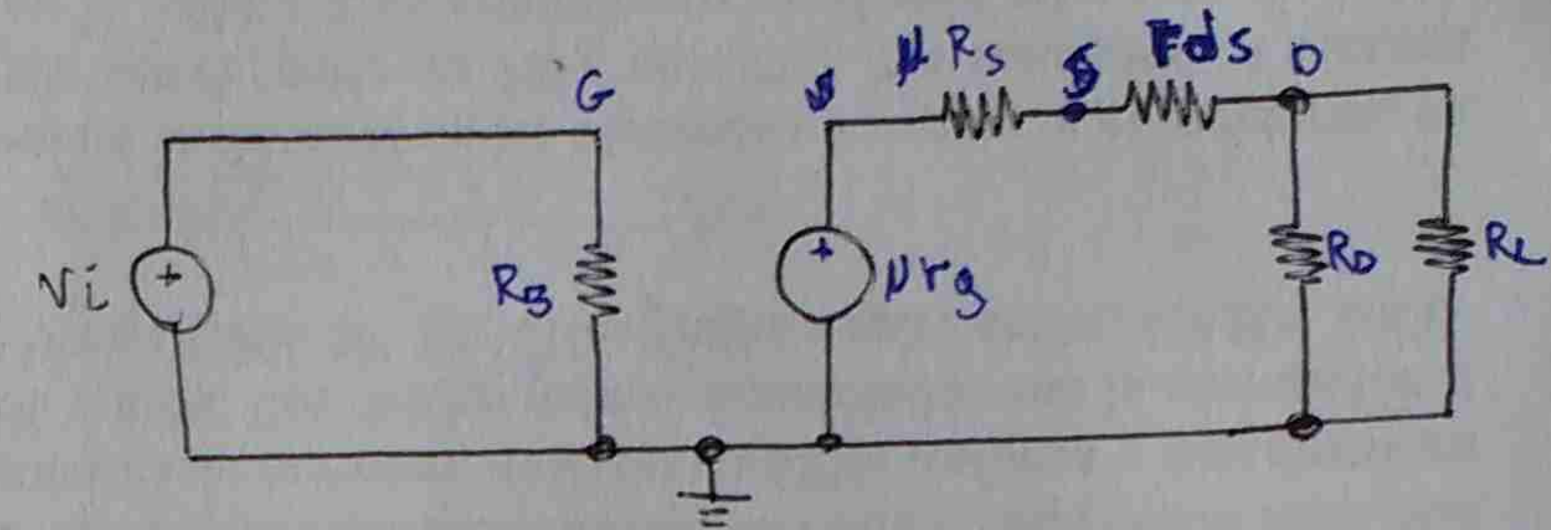
$$\boxed{R_G = R_1 // R_2}$$

$$\boxed{I_G = 0}$$

LKT. $\boxed{V_{GSQ} = V_{GG} - I_{DQ} R_S}$

$$\boxed{\frac{\mu}{r_{ds}} = g_m}$$

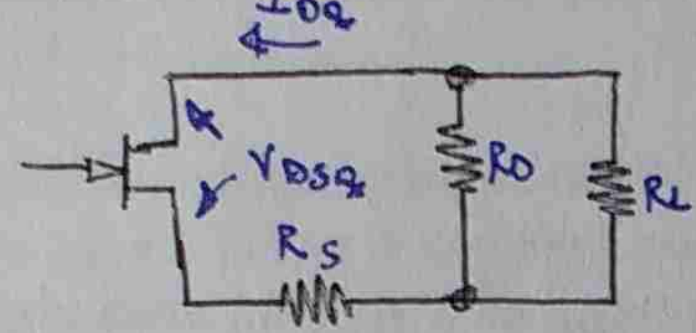
Malla salida $\boxed{V_{DD} = V_{DSQ} + I_{DQ}(R_S + R_D)}$



Para MES:

$\hat{i}_{D-max} = I_{DQ}$

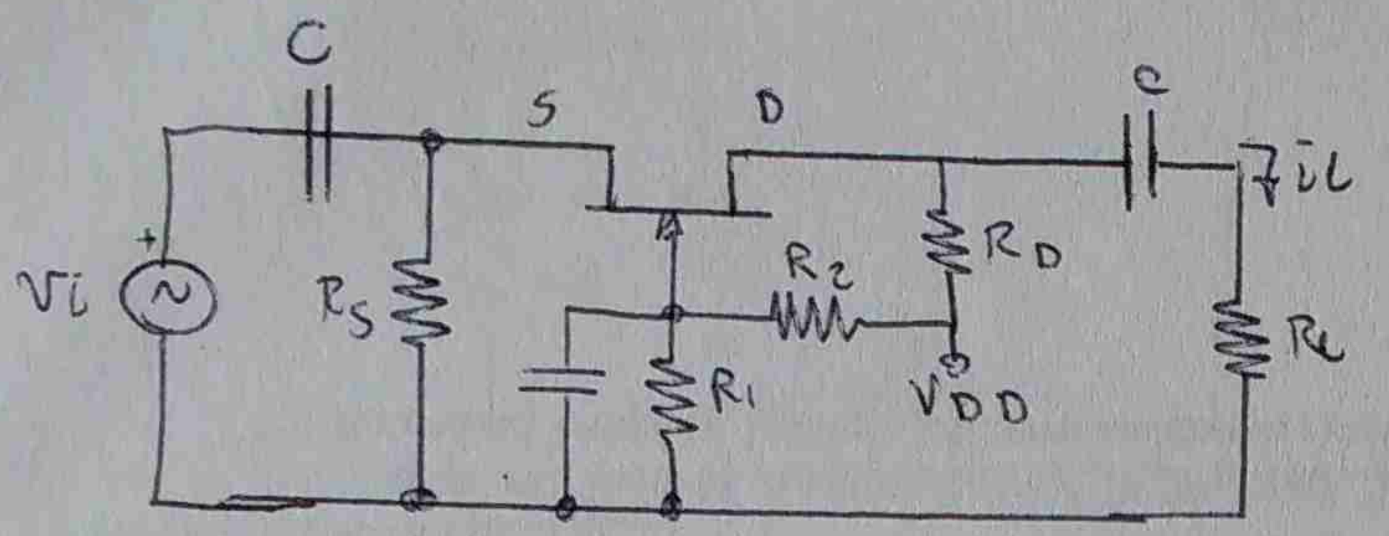
$\hat{V}_{DS-max} = V_{DSQ}$

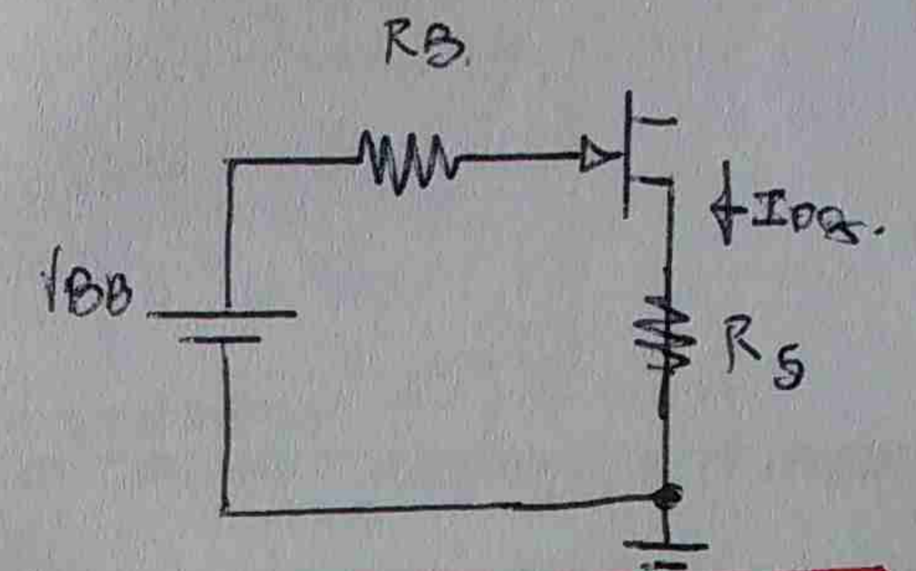


$$\boxed{V_{DSQ} = I_{DQ}\left[R_S + (R_D // R_L)\right]}$$

caso para MES sin/cap

Compuerto común



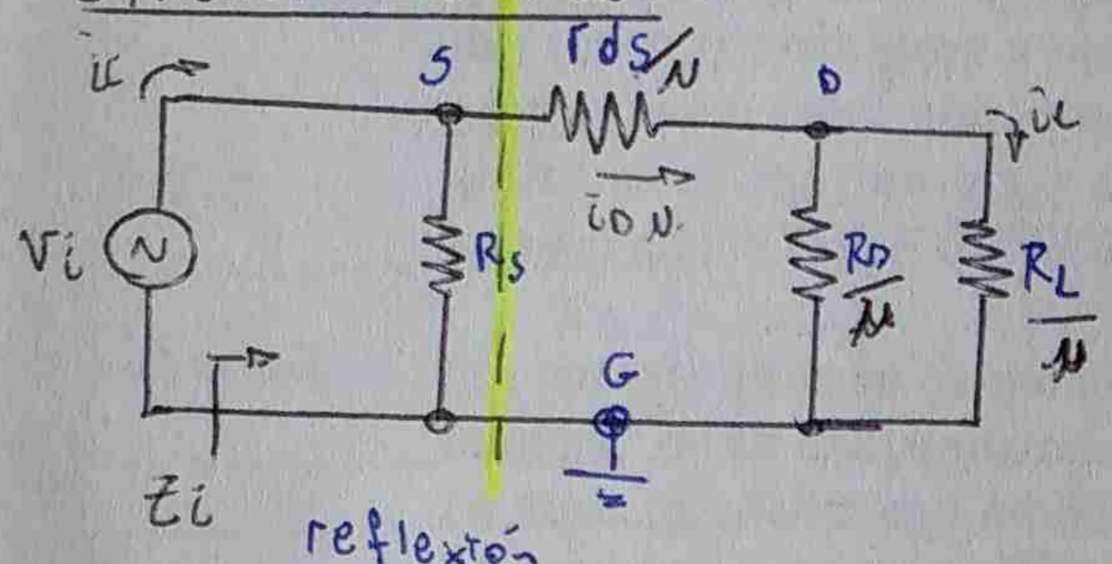


$$\boxed{V_{DD} = V_{DSQ} + I_{DQ}(R_S + R_D)}$$

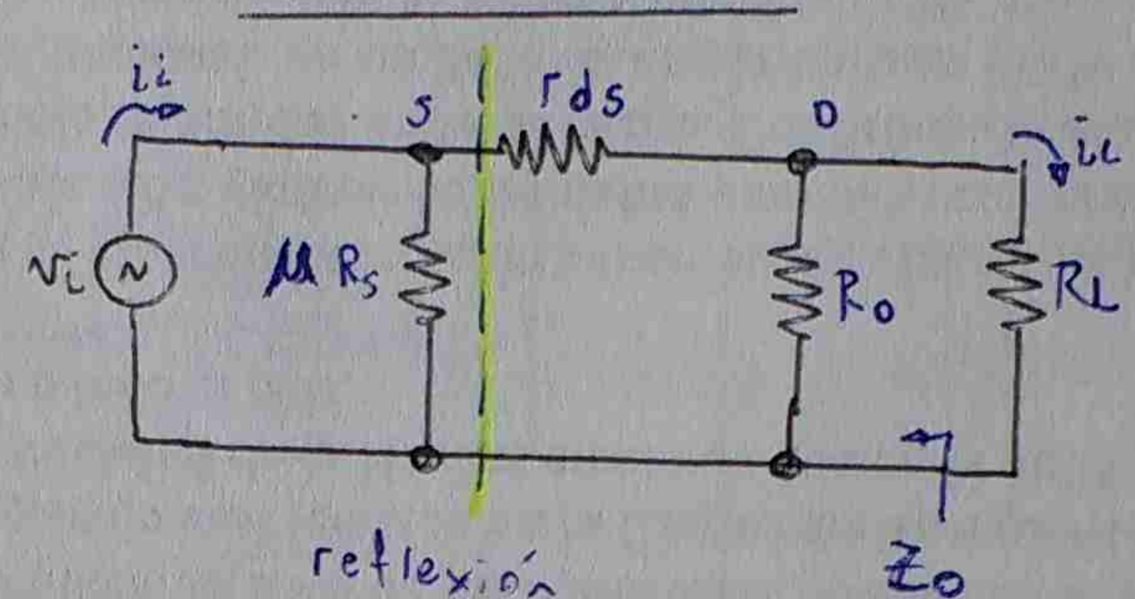
$$\boxed{V_{BB} = V_{GSQ} + I_{DQ} R_S}$$

$$\boxed{\frac{\mu}{r_{ds}} = g_m}$$

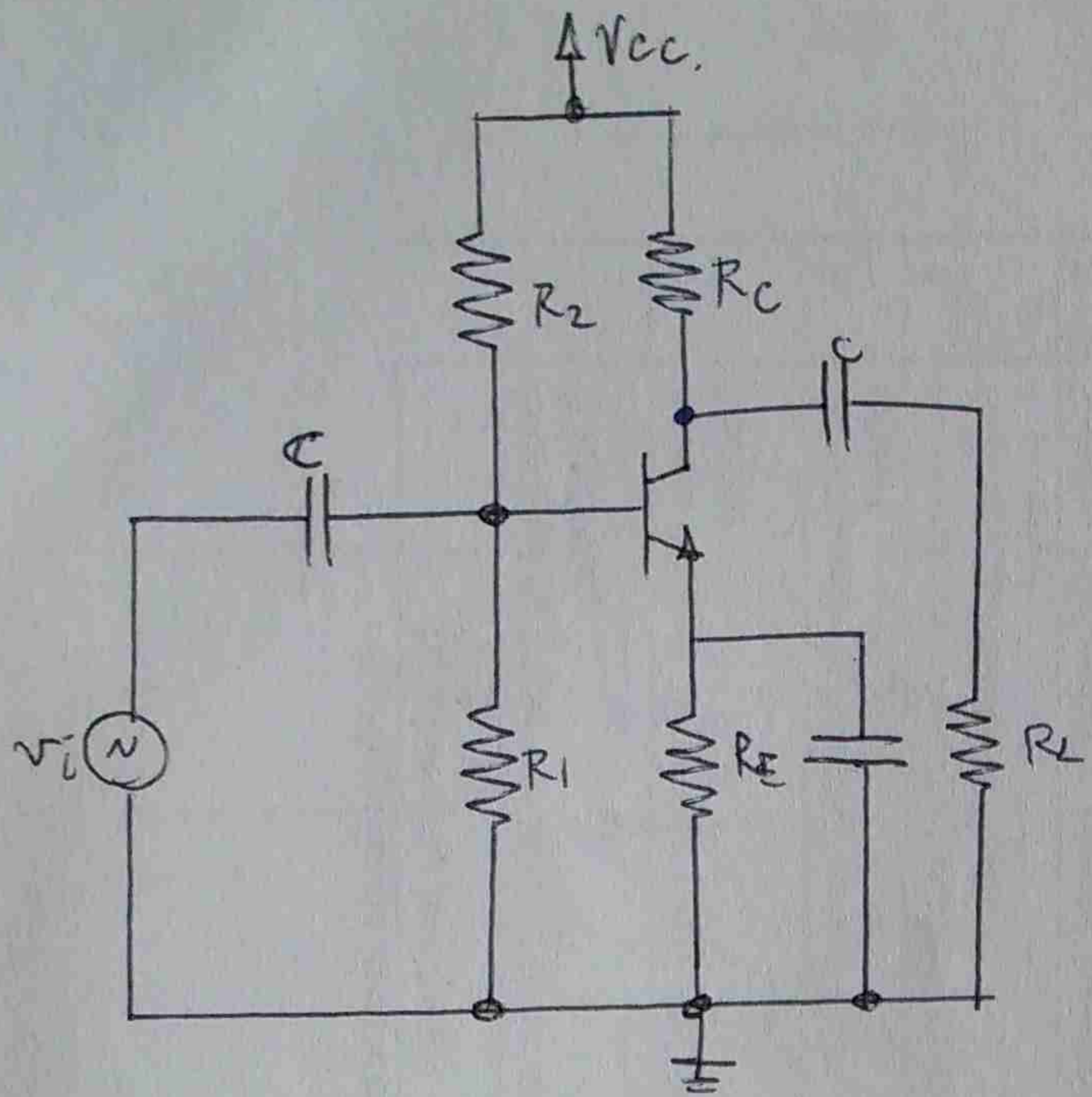
circuito entrada.



circuito salida.



Amplificador Emisor común con Cap. desacople



$$I_{CQ} = \frac{V_{BB} - V_{BE}}{\frac{R_B}{\beta} + R_E}$$

$$V_{CEQ} = V_{CC} - I_{CQ}(R_C + R_E)$$

$$h_{ie} = h_{fe} \frac{25mV}{I_{CQ}}$$

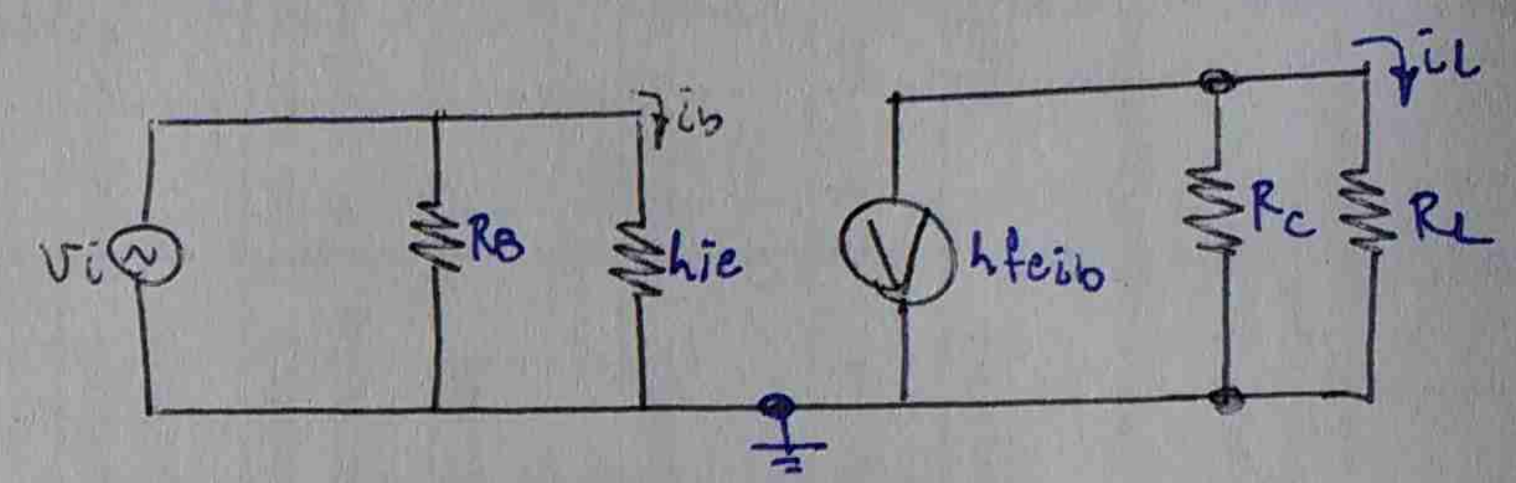
MES

$$I_{CQ\,MES} = \frac{V_{CC}}{R_C + R_E + R_E // R_L}$$

$$P_{L\,max} = \frac{I_{CQ}^2}{8} R_L$$

$$\hat{i}_{L\,max} = \frac{i_{C\,max}}{2} = \frac{I_{CQ}}{2}$$

$$P_{CC\,max} = V_{CC} I_{CQ}$$



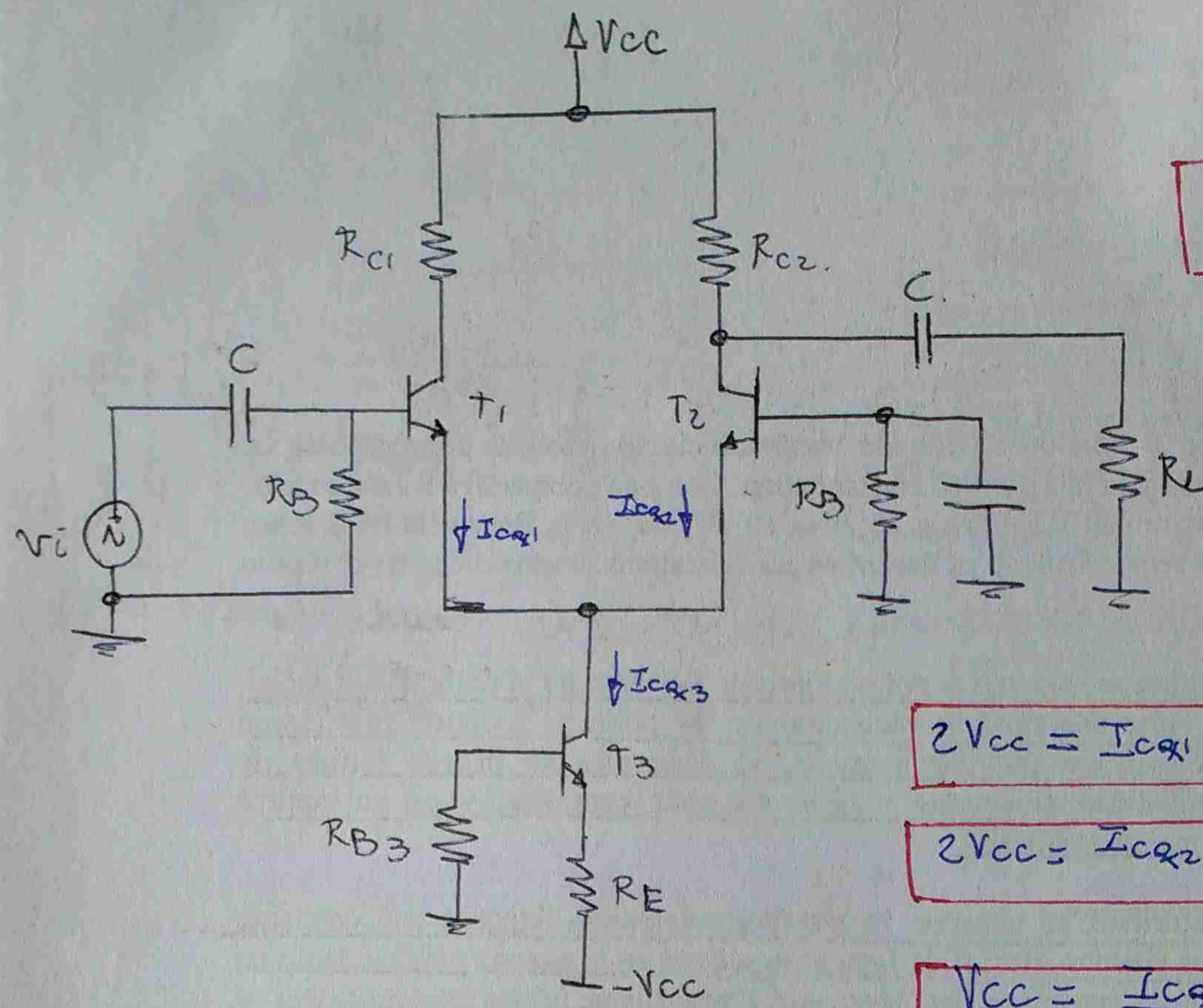
Parametros estabilidad

$$S_V = -\frac{1}{R_E}$$

$$S_I = 1 + \frac{R_B}{R_C}$$

$$S_\beta = \frac{I_{CQ}}{\beta_1}$$

Amplificador Diferencial con 3 transistores



$$\boxed{I_{CQ1} = I_{CQ2} = \frac{I_{CQ3}}{2}}$$

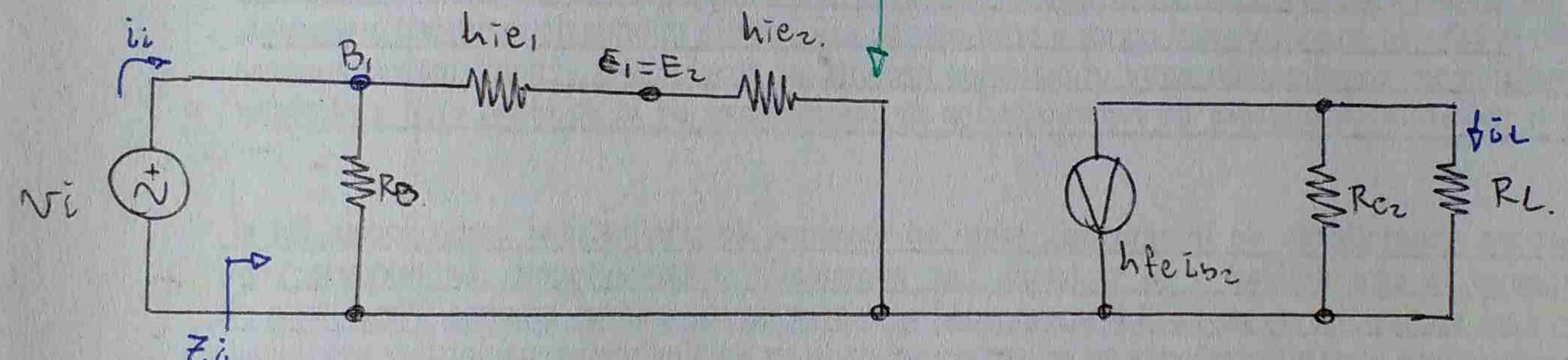
$$\boxed{2V_{CC} = I_{CQ1} R_{C1} + V_{CEQ1} + V_{CEQ3} + I_{CQ3} \cdot R_E}$$

$$\boxed{2V_{CC} = I_{CQ2} R_{C2} + V_{CEQ2} + V_{CEQ3} + I_{CQ3} R_E}$$

$$\boxed{V_{CC} = \frac{I_{CQ2}}{h_{fe}} R_B + V_{BE} + V_{CEQ3} + R_E I_{CQ3}}$$

Circuito equivalente entrada.

El capacitor pone a masa a B_2



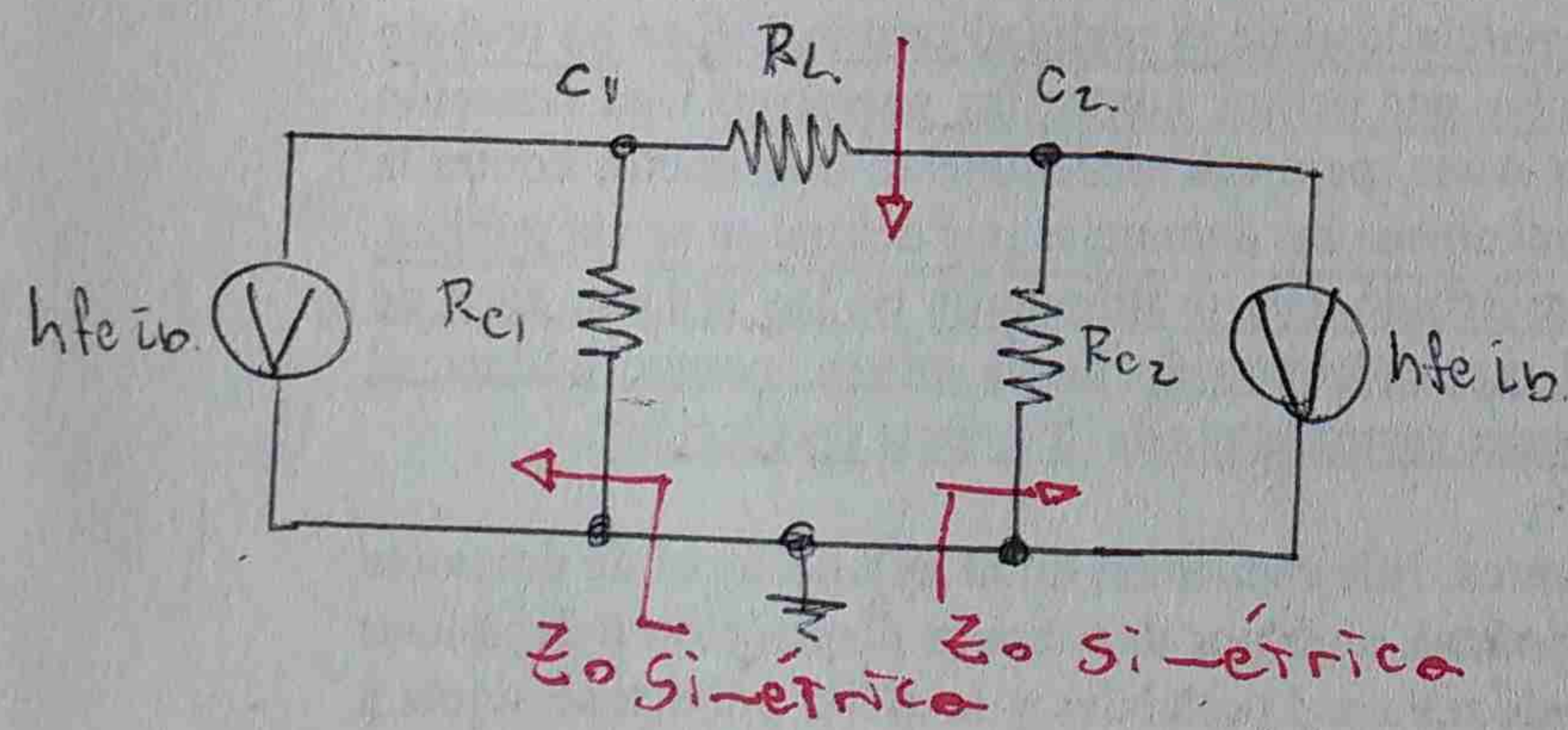
Ganancia modo común

Ganancia modo dif.

$$\boxed{i_L = \Delta_c \, i_c + \Delta_d \, i_d}$$

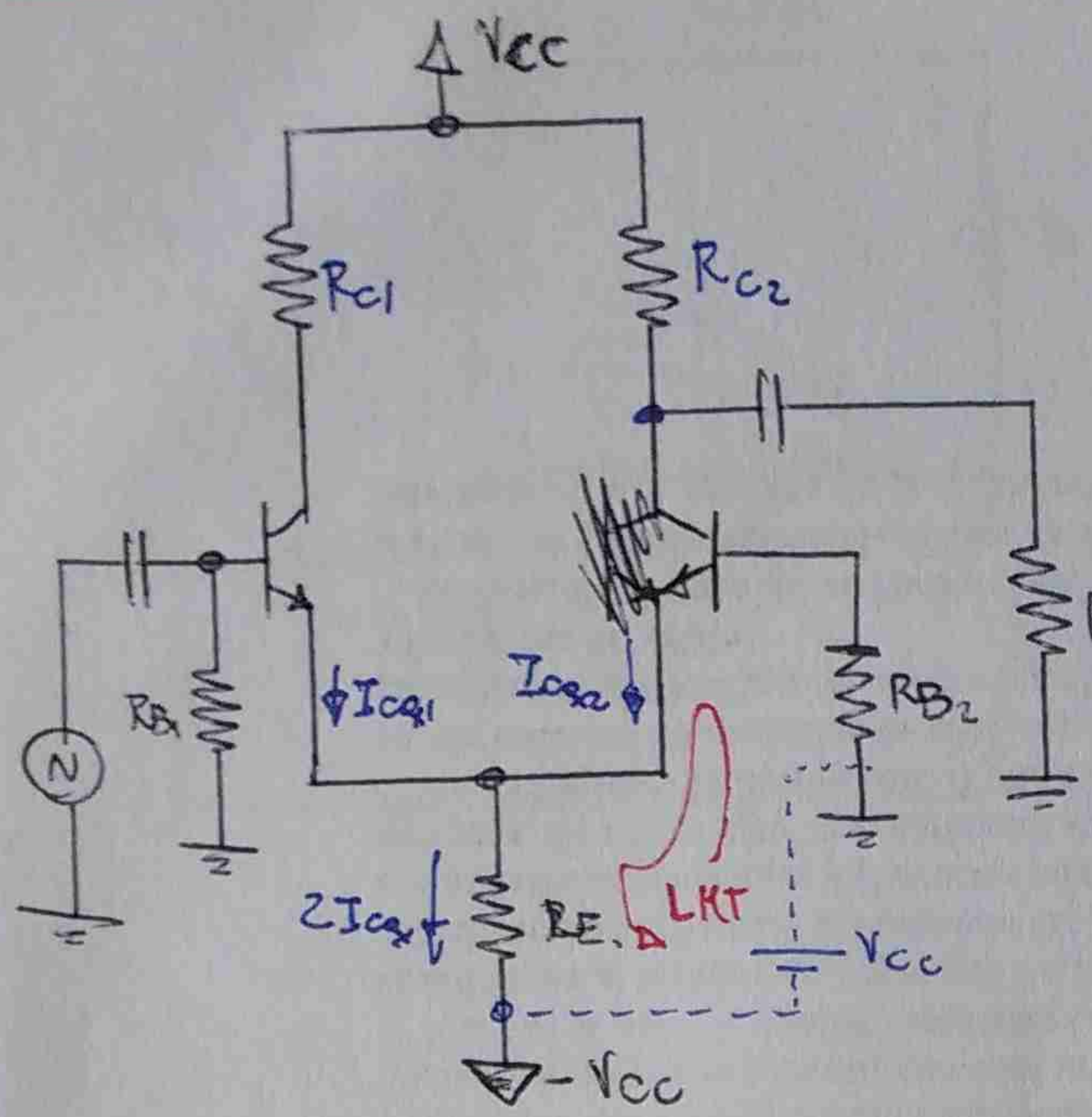
Corriente modo común

Zo diferencial



$$\boxed{RRMC = \frac{\Delta d}{\Delta c}}$$

Amplificador Diferencial



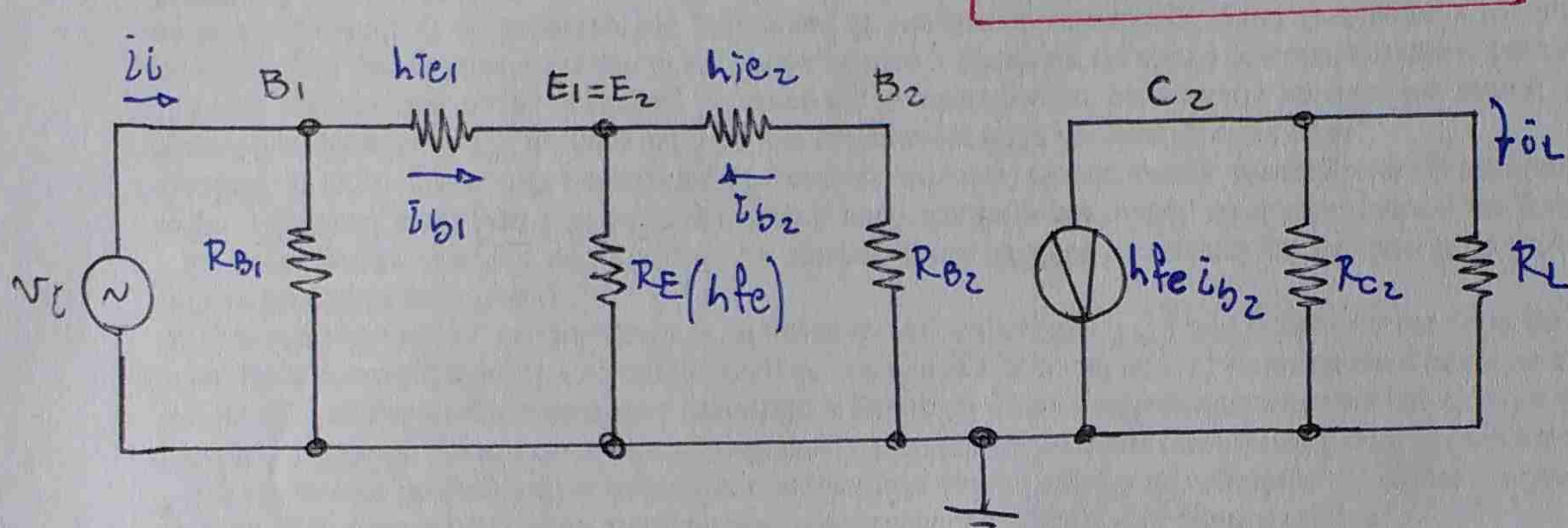
$$\boxed{I_{cq1} = I_{cq2}}$$

$$\boxed{V_{CC} = \frac{I_{cq}}{\beta} \cdot R_{B2} + V_{BE} + 2 I_{cq} R_E}$$

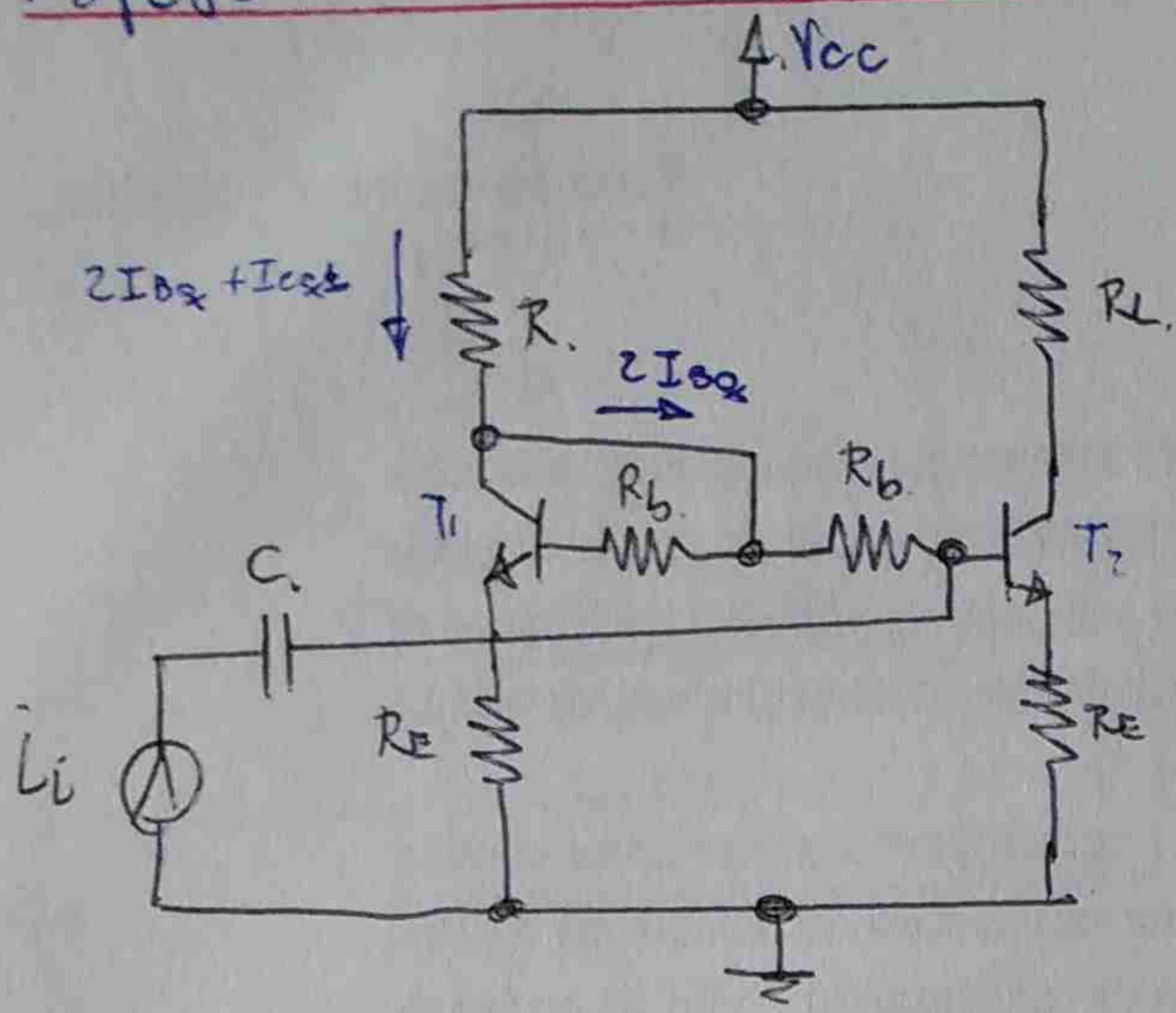
$$\boxed{V_{CEq1} = 2V_{CC} - I_{cq}\left(R_{C1} + 2R_E\right)}$$

$$\boxed{V_{CEq2} = 2V_{CC} - I_{cq}\left(R_{C2} + 2R_E\right)}$$

$$\boxed{I_{cq} = \frac{V_{EE} - V_{BE}}{\frac{R_B}{\beta} + 2R_E}}$$

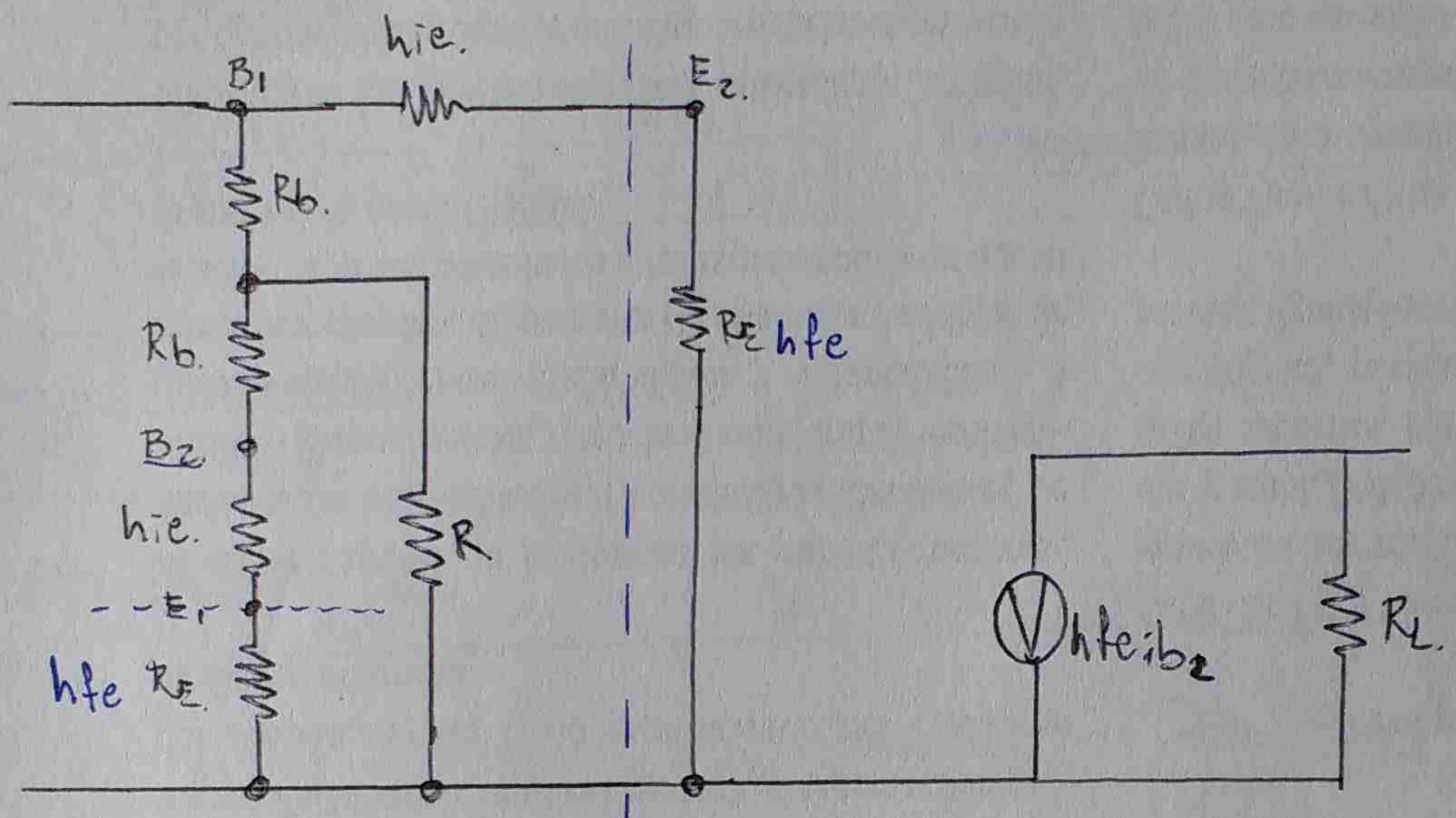


Espejo corriete. con Res.

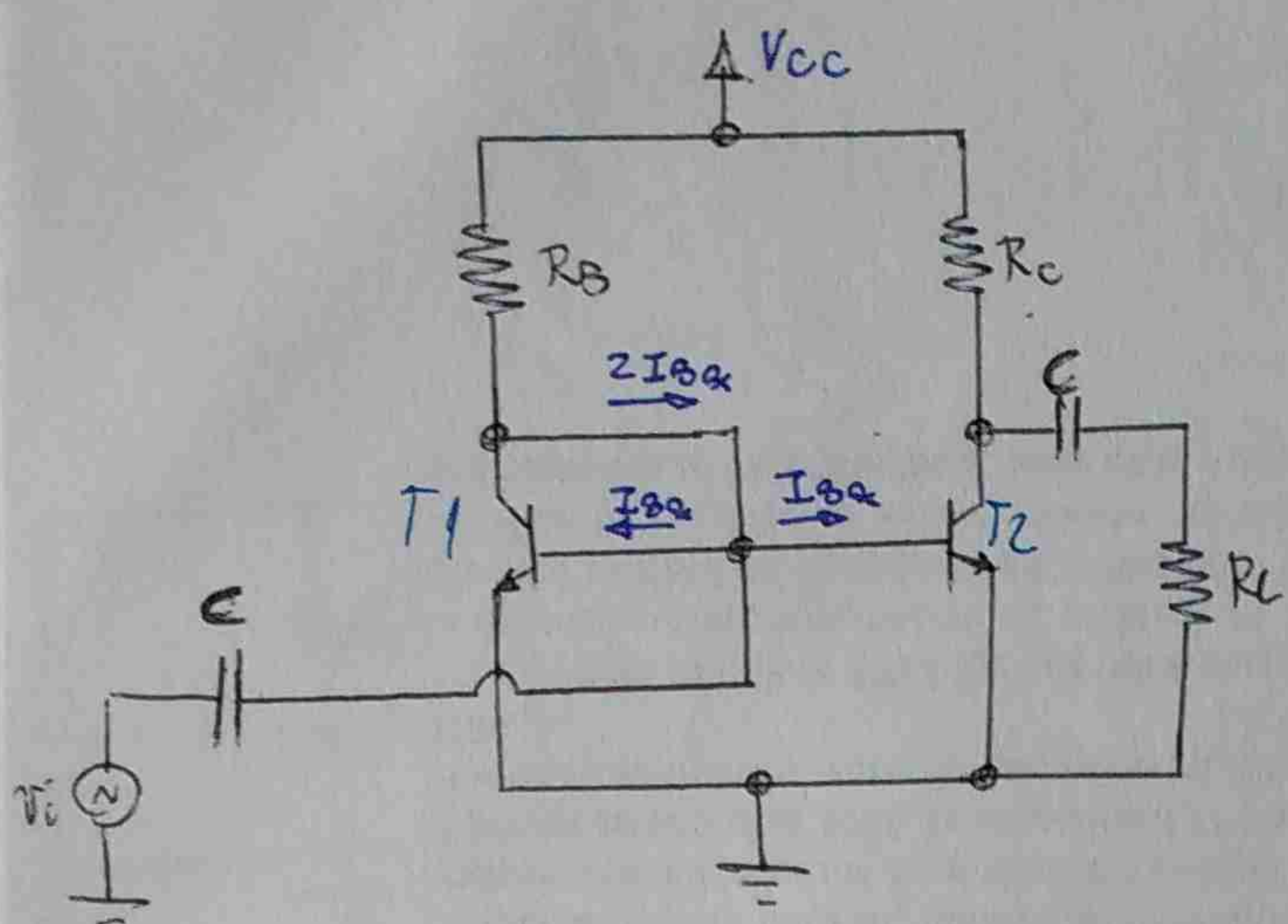


$$\boxed{V_{CC} = \left(2\frac{I_{BQ}}{h_{fe}} + I_{CQ}\right) R + \frac{I_{CQ}}{h_{fe}} R_b + V_{BE} + R_E I_{CQ}}$$

$$\boxed{V_{CEQ2} = V_{CC} - I_{CQ}\left(R_L + R_E\right)}$$



Polarización Balanceada en circuitos integrados



$$\boxed{I_{CQ2} = \frac{V_{CC} - V_{BE}}{R_B}}$$

$$\boxed{V_{CEQ2} = V_{CC} - I_{CQ2} R_C}$$

$\boxed{I_{CQ1} = I_{CQ2}}$ Espejo de corrientes

$\boxed{V_{CEQ1} = 0.7}$ Lo utilizo como diodo

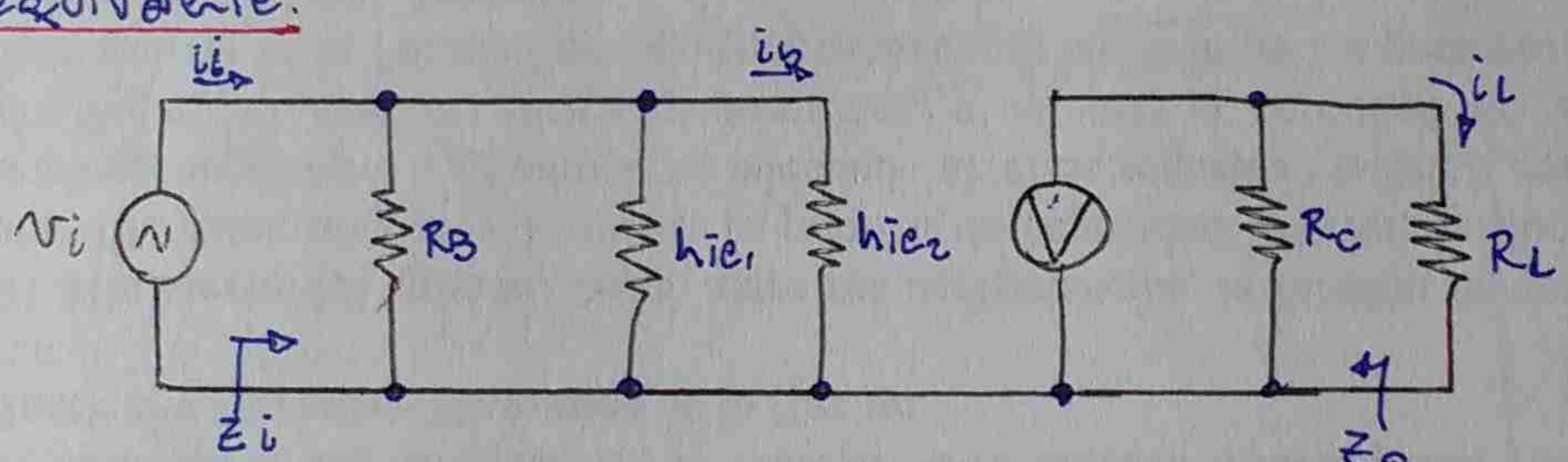
Rediseño para MES

$$I_{CQ\,MES} = \frac{V_{CC}}{R_{CC} + R_{CA}} = \boxed{\frac{V_{CC}}{R_C + R_C /\!/ R_L}}$$

$$\boxed{V_{CEQ2MES} = V_{CC} - I_{CQ2MES} R_C}$$

$$\boxed{R_{B\,MES} = \frac{V_{CC} - V_{BE}}{I_{CQMES}}}$$

Circuito equivalente.



$$\boxed{h_{ie1} = \frac{25mV\ \cancel{h_{fe}}}{I_{CQ1}}}$$

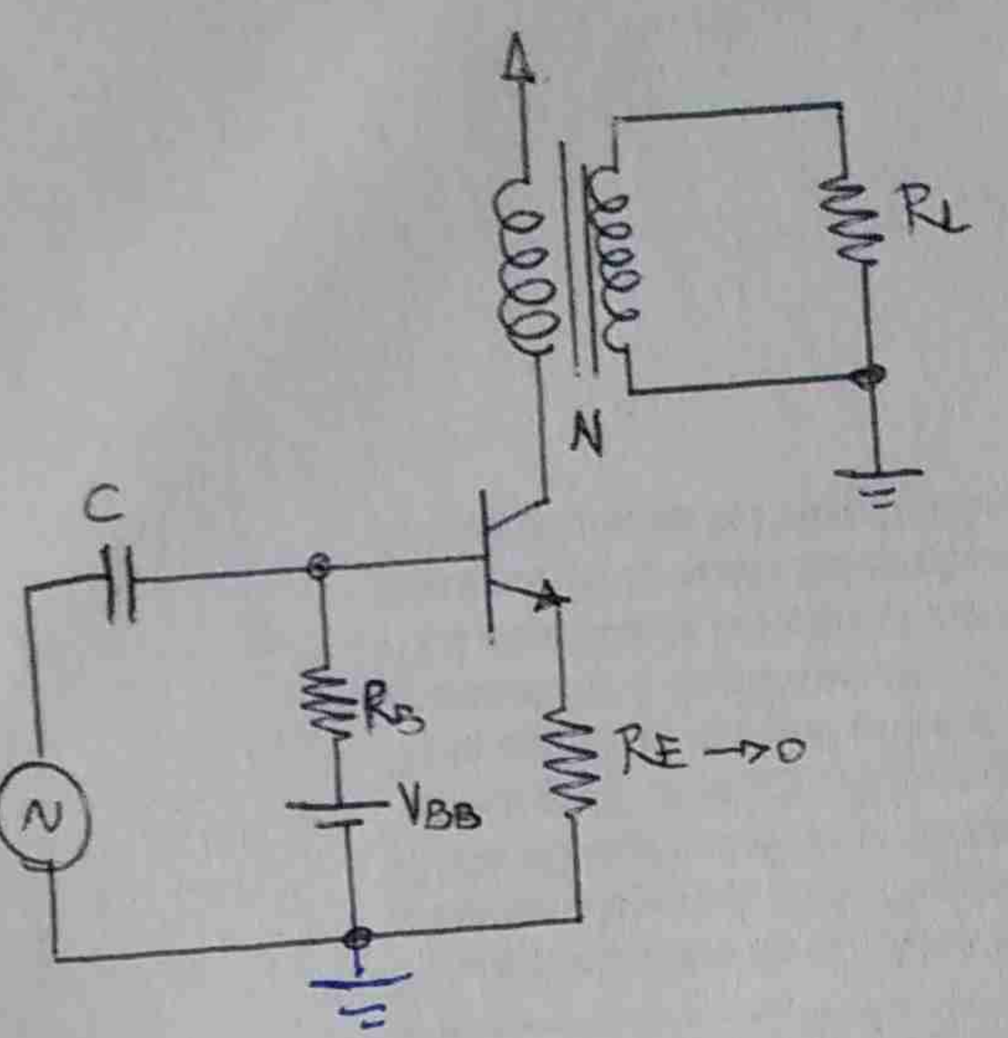
$$\boxed{Z_i = R_B /\!/ \frac{h_{ie}}{2}}$$

$$A_i = \frac{i_L}{i_i} = \frac{i_L}{i_b} \cdot \frac{i_b}{i_i} = \boxed{- \frac{R_C}{R_C + R_L} \cdot h_{fe} \cdot \frac{R_B /\!/ h_{ie1}}{R_B /\!/ h_{ie1} + h_{ie2}}}$$

$$\boxed{\Delta I_{CQ} = \frac{K\ \Delta T}{R'_B}}$$

Amplificador clase A con acoplamiento por transformador

$\eta = 50\%$



$$\boxed{R'_L = N^2 R_L}$$

$$\boxed{R_B = \left(\frac{V_{CC} - V_{BE}}{I_{CQ}}\right)\beta}$$

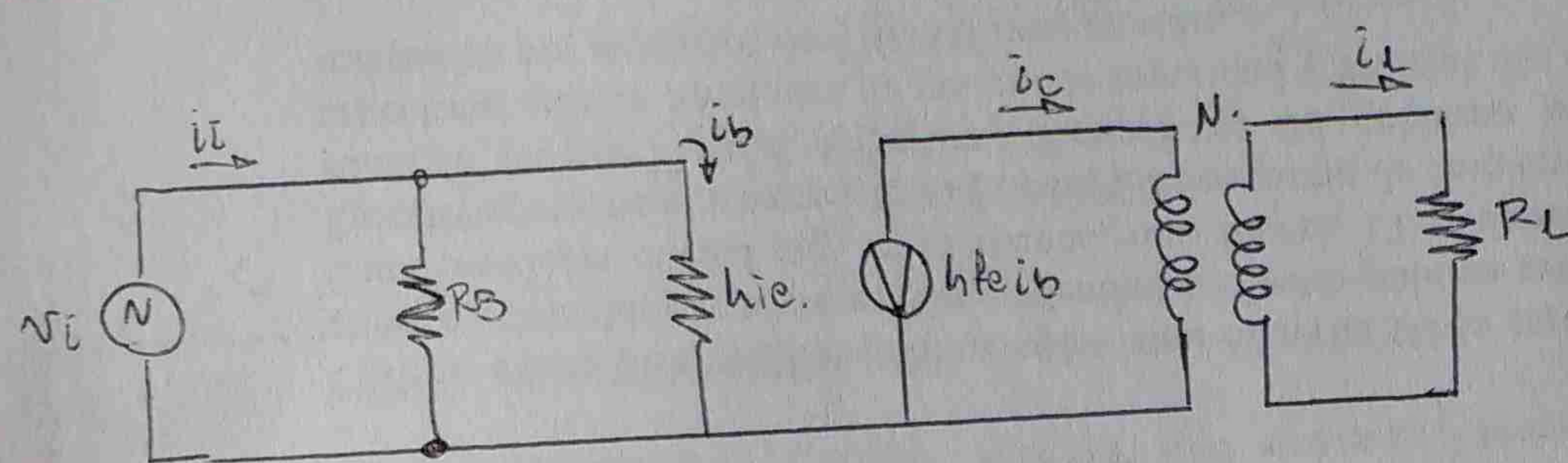
$$\boxed{P_{Lmax} = \frac{V_{CC}^2}{2N^2R_L}}$$

$$\boxed{P_{Cmax} = V_{CC}\, I_{CQ}}$$

$$\boxed{V_{CC} = N\sqrt{2P_{Lmax}R_L}}$$

$$\boxed{I_{CQ} = \frac{V_{CC}}{N^2R_L}}$$

$$\boxed{I_{CQ} = \frac{25\,mV}{h_{ib}}}$$

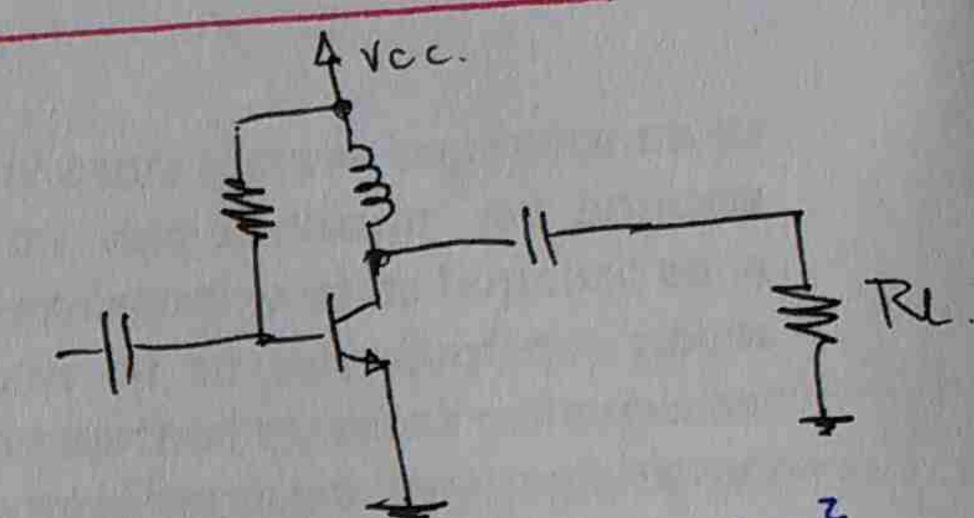


$$A_v = \frac{v_L}{v_i} = \frac{v_L}{v_c}\,\frac{v_c}{i_b}\,\frac{i_b}{v_i} = \frac{1}{N}\,\cancel{h_{fe}}\,R'_L\,\frac{1}{\cancel{h_{fe}}\,h_{ib}} = \frac{R'_L}{N\,h_{ib}}$$

$$v_L = \frac{v_c}{N} \Rightarrow \frac{v_L}{v_c} = \frac{1}{N}$$

$$v_c = h_{fe}\, i_b\, R'_L \Rightarrow \frac{v_c}{i_b} = h_{fe} R'_L$$

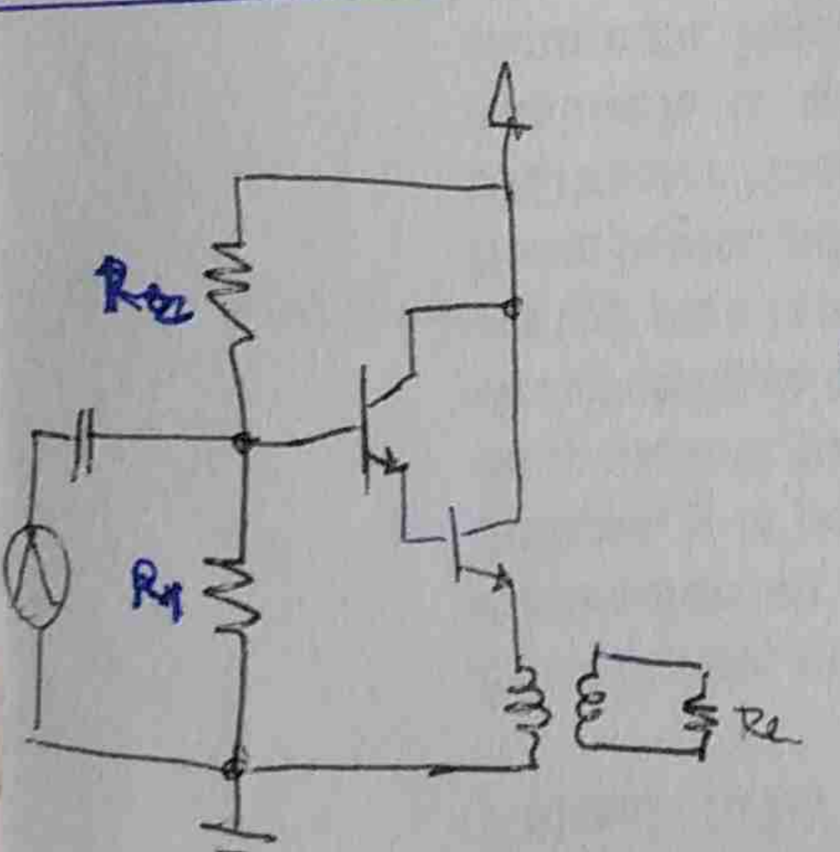
$$i_b = \frac{v_i}{h_{ie}} \Rightarrow \frac{i_b}{v_i} = \frac{1}{h_{ie}} = \frac{1}{h_{fe}h_{ib}}$$

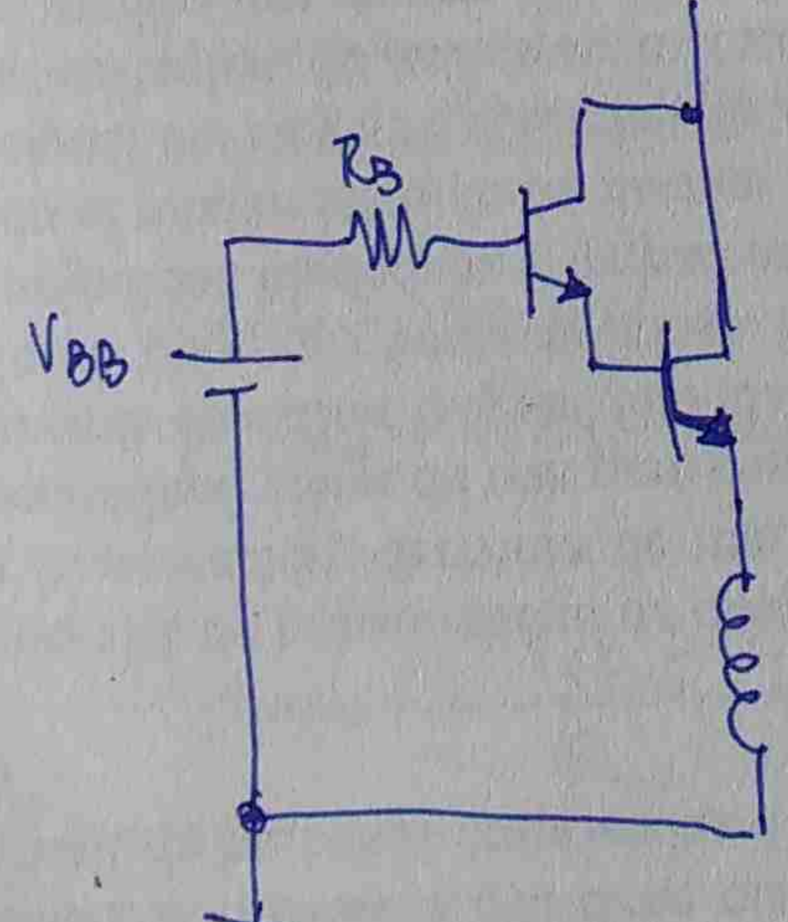


$$FM = 2 = \frac{P_{Cmax}}{P_{Lmax}} \Rightarrow \frac{V_{CC}^2}{2R_L} = \frac{P_{Cmax}}{2}$$

$$P_{Cmax} = \frac{V_{CC}^2}{R_L}$$

$$I_{CQ} = \frac{V_{CC}}{R_L}$$

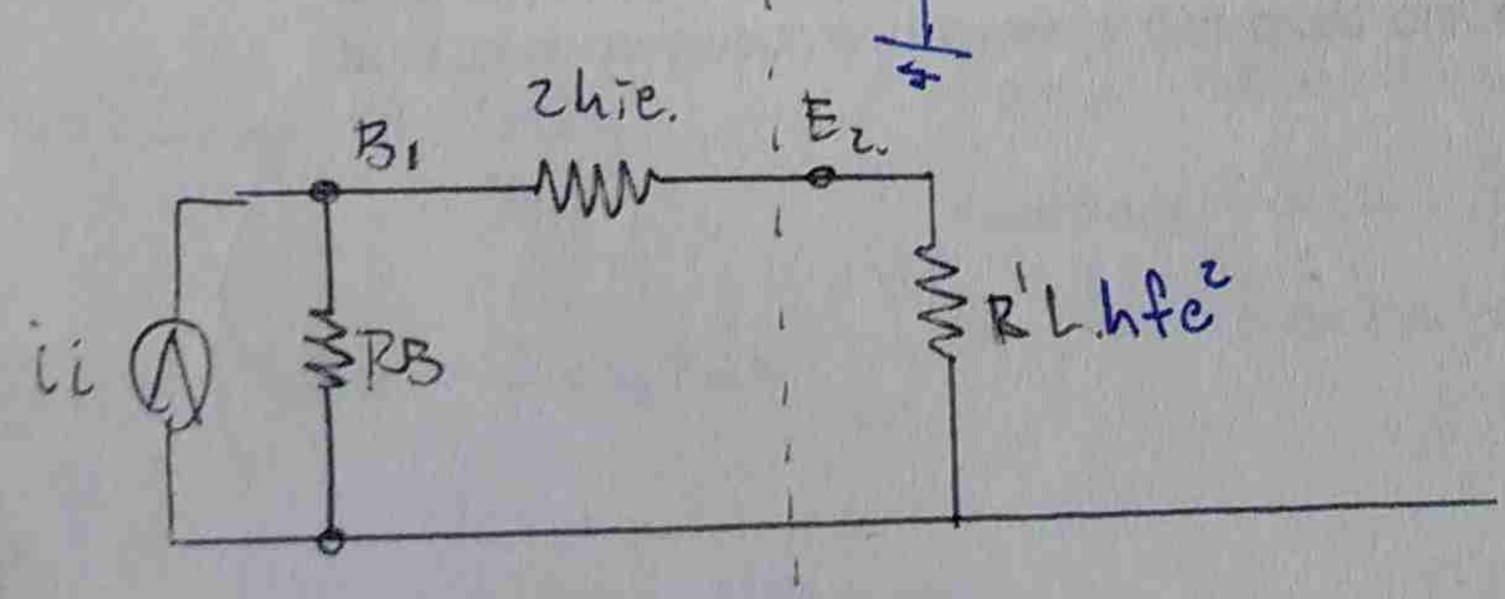




$$\boxed{V_{BB} = R_B\,\frac{I_{CQ2}}{h_{fe}^2} + 2V_{BE}}$$

$$\boxed{V_{CEQ2} = V_{CC}}$$

$$\boxed{V_{CEQ1} = V_{CEQ2} - V_{BE}}$$



1

$$\alpha = \frac{\beta}{\beta+1}$$

$$\beta = \frac{\alpha}{1-\alpha}$$

$$I_C = \alpha I_E + I_{CBO} \rightarrow I_E = \frac{I_C - I_{CBO}}{\alpha}$$

$$I_E = I_C + I_B$$

$$I_B = I_E - I_C = I_E - \alpha I_E - I_{CBO}$$

$$I_B = \frac{I_C - I_{CBO}}{\alpha}(1-\alpha) - I_{CBO}$$

$$= \frac{I_C}{\alpha}(1-\alpha) - \frac{I_{CBO}}{\alpha}(1-\alpha) - I_{CBO}$$

$$= I_C \frac{1-\alpha}{\alpha} - I_{CBO}\left(\frac{1-\alpha+\alpha}{\alpha}\right)$$

$$\boxed{I_B = I_C\left(\frac{1-\alpha}{\alpha}\right) - \frac{I_{CBO}}{\alpha}}$$

MES: El punto Q se encuentra en la mitad de la recta de carga de Alterna (CA)

- Si está diseñado para MES puede no estar funcionando para MES
- Si esta funcionando para MES, es porque fué diseñado para MES

En CC $\quad V_{CC} = V_{CEQ} + I_{CQ} R_{CC}$ (1)

CA $\quad v_{ce\,max} = i_{c\,max} R_{CA}$

MES $\begin{cases} i_{c\,max} = I_{CQ\,MES} \\ v_{ce\,max} = V_{CEQ\,MES} \end{cases}$

$$V_{CEQ\,MES} = I_{CQ\,MES} R_{CA}$$

Reemplazo en (1) $\quad V_{CC} = I_{CQ\,MES} R_{CA} + I_{CQ\,MES} R_{CC}$

$$\boxed{I_{CQ\,MES} = \frac{V_{CC}}{R_{CA} + R_{CC}}}$$ Formula General

Emisor Común

$$I_{CQ\,MES} = \frac{V_{CC}}{R_C + R_E + R_C // R_L}$$

Si $V_{CEsat} \neq 0$

MES $\begin{cases} i_{c\,max} = I_{CQ} \\ v_{ce\,max} = V_{CEQ} - V_{CEsat} \end{cases}$

$$\boxed{I_{CQ\,MES} = \frac{V_{CC} - V_{CESAT}}{R_{CC} + R_{CA}}}$$

$$i_C = I_{CQ} + \frac{V_{CEQ}}{R_{CA}}$$

$$V_{CE} = V_{CEQ} + I_{CQ} R_{CA}$$

para encontrar los cortes con los ejes, de la Recta de CA

$\downarrow$

máxima señal en alterna

②

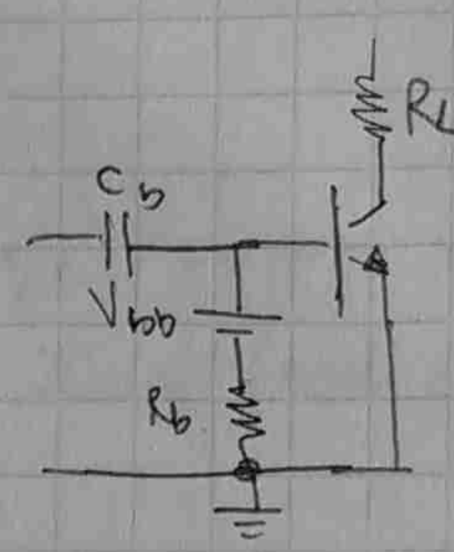
Potencia promedio

$$p(t) = V_{AV} I_{AV} + \frac{1}{T}\int_0^T v(t)\, i(t)\, dt$$

$P_{cc} = V_{cc} I_{cq}$

Para max.

$$P_{cc\,max} = \frac{V_{cc}^2}{2R_L}$$



Potencia en la carga

$$P_{L(CA)} = \frac{1}{2} \hat{i}_c^{\,2} R_L$$

Rendimiento:

$$\eta = \frac{P_L}{P_{cc}}$$

Potencia útil en la carga

Potencia de la fuente de Alimentación

Para la config anterior

$$P_{L\,max} = \frac{V_{cc}^2}{8R_L} \qquad P_{cc\,max} = \frac{V_{cc}^2}{2R_L}$$

$$\boxed{\eta = 0.25 = 25\%}$$

Factor

Factor de Mérito

$$\boxed{F_M = \frac{P_{C\,máx}}{P_{L\,máx}}}$$

Potencia máxima disipada en el colector

" " " " la carga

3

$P_{C\,máx}$ ocurre sin señal

$P_{L\,máx}$ Con señal máxima

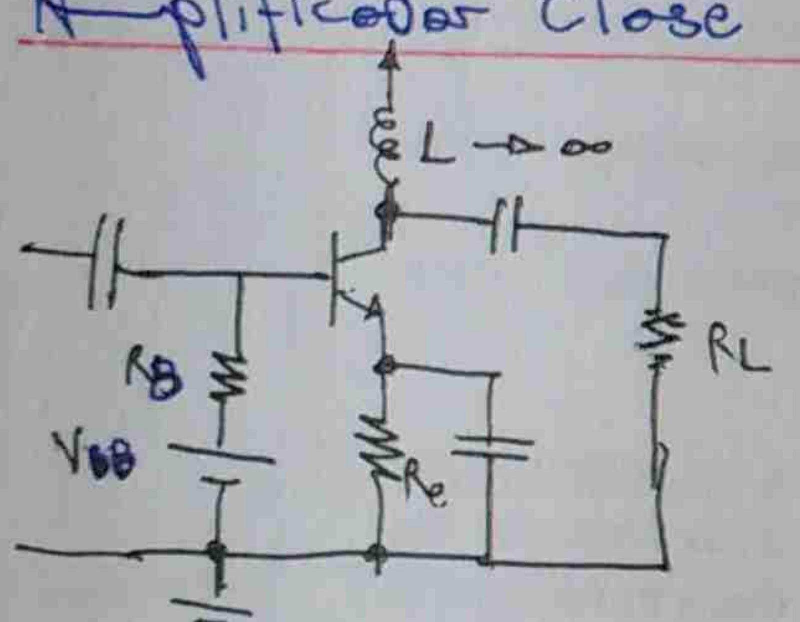
Para MES

$$F_M = \frac{\frac{V_{CC}^2}{4R_L}}{\frac{V_{CC}^2}{8R_L}} = 2$$

Teniendo como dato $P_{L\,máx}$ y utilizando el 0,25 (25%) como valor máximo para MES, y también conociendo Vcc, se despeja el I_{CQ} (que será para MES y máximo rendimiento)

$$\eta_{max} = \frac{P_{L\,máx}}{P_{CC\,máximo}} = 0.25 \Rightarrow P_{C\,max} = \frac{P_{L\,máx}}{0.25} = V_{CC}\, I_{CQ\,MES} \Rightarrow \boxed{I_{CQ\,MES} = \frac{P_{L\,máx}}{0.25\, V_{CC}}}$$

Amplificador Clase A con acoplamiento por inductor



$R_{CC} \simeq 0$

circ. abierto para CA

$R_{CA} = R_L // X_L \simeq R_L$

Si $R_E \to 0$, ¿Quién limita a I_{CQ}?

$$I_{CQ} = \frac{V_{BB} - V_{BE}}{\frac{R_B}{\beta} + \cancel{R_E}}$$

R_B limita a I_{CQ}

Antes.

$2V_{CEQ} < V_{CC}$

$V_{BCEO} < V_{CC}$

Ahora.

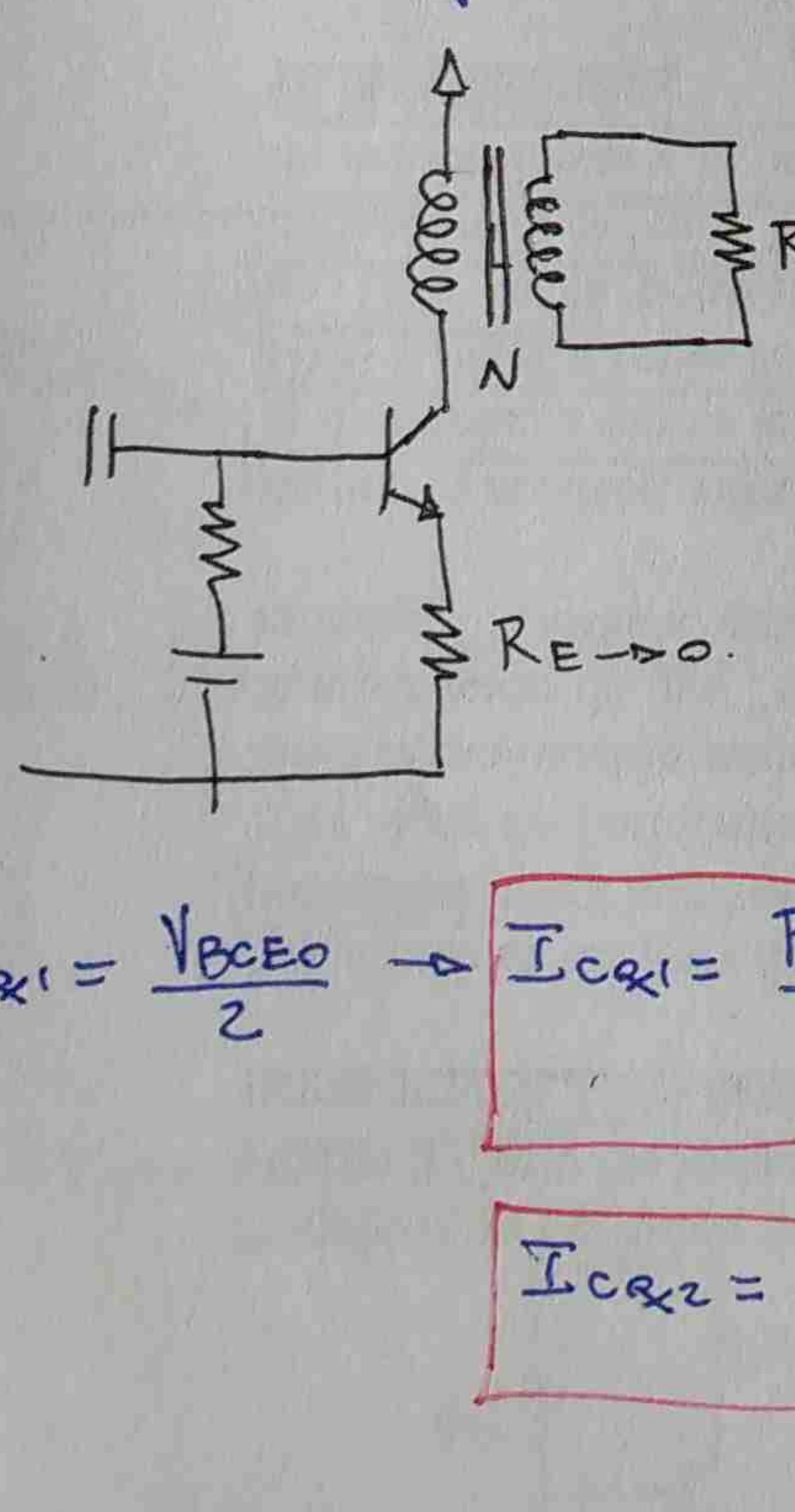
$V_{BVCEO} < 2V_{CC}$

$V_{CC} < \frac{V_{BCEO}}{2}$

Máxima Potencia

C/$R_L = R_C$	C/Choque Bobina
$P_{CC} = V_{CC} \cdot I_{CQ}$	
$P_{LCC\,max} = \frac{V_{CC}^2}{2R_L}$	$P_{LCC\,max} = \frac{V_{CC}^2}{R_L}$
$P_{LCA\,max} = \frac{V_{CC}^2}{8R_L}$	$P_{LCA\,max} = \frac{V_{CC}^2}{2R_L}$
$P_C = P_{CC} - P_{LCC} - P_{LCA}$	$P_C = P_{CC} - P_{LCA}$
$P_{C\,max} = \frac{V_{CC}^2}{4R_L}$	$P_{C\,max} = \frac{V_{CC}^2}{R'_L}$
$P_{C\,min} = \frac{V_{CC}^2}{8R_L}$	$P_{C\,min} = \frac{V_{CC}^2}{2R_L}$
$\eta_{max} = 25\%$	$\eta_{max} = 50\%$
FM=2	

Amplificador clase A por acoplamiento por ~~inductor~~ transformador



Es igual al anterior solo que

$$\boxed{R'_L = N^2 R_L}$$

N debe estar entre determinados valores.

$$\boxed{N_{max} = \frac{1}{I_{CQ1}}\sqrt{\frac{2P_{L\,max}}{R_L}}} \qquad \boxed{N_{min} = \frac{1}{I_{CQ2}}\sqrt{\frac{2P_{L\,max}}{R_L}}}$$

$$V_{CEQ1} = \frac{V_{BCEO}}{2} \rightarrow \boxed{I_{CQ1} = \frac{P_{C\,max}}{V_{CEQ1}}}$$

$$N = \frac{N_{max} + N_{min}}{2}$$

$$\boxed{V_{CC} = N\sqrt{2P_{L\,max}\,R_L} = V_{CEQ}}$$

$$\boxed{I_{CQ2} = \frac{i_{C\,max}}{2}}$$

$$\boxed{R_b = \left(\frac{V_{CC} - V_{be}}{I_{CQ}}\right)\beta}$$

Estabilidad Polarización (carpeta)

Cuanto menores sean los factores de estabilidad, mayor será la estabilidad ΔI_{CQ} (S)

Analisis de los factores de estabilidad

$$\frac{\partial I_{CQ}}{\partial T} = \frac{\partial I_{CQ}}{\partial V_{BE}}\frac{dV_{BE}}{dT} + \frac{\partial I_{CQ}}{\partial I_{CBO}}\frac{dI_{CBO}}{dT} + \frac{\partial I_{CQ}}{\partial \beta}\frac{d\beta}{dT} + \ldots$$

$$\frac{\Delta I_{CQ}}{\cancel{\Delta T}} = \frac{\Delta I_{CQ}}{\Delta V_{BE}}\frac{\Delta V_{BE}}{\cancel{\Delta T}} + \frac{\Delta I_{CQ}}{\Delta I_{CBO}}\frac{\Delta I_{CBO}}{\cancel{\Delta T}} + \frac{\Delta I_{CQ}}{\Delta \beta}\frac{\Delta \beta}{\cancel{\Delta T}}$$

$$\Delta I_{CQ} = S_V \; \Delta V_{BE} + S_I \; \Delta I_{CBO} + S_\beta \; \Delta\beta$$

Factores de estabilidad

Si $\alpha = 1$. (de la fórmula general)

$$I_{CQ} = \frac{V_{BB} - V_{BE}}{R_E} + I_{CBO}\left(1 + \frac{R_B}{R_E}\right)$$

$$S_V = \frac{\partial I_{CQ}}{\partial V_{BE}} = -\frac{1}{R_E}$$

$$S_I = \frac{\partial I_{CQ}}{\partial I_{CBO}} = 1 + \frac{R_B}{R_C}$$

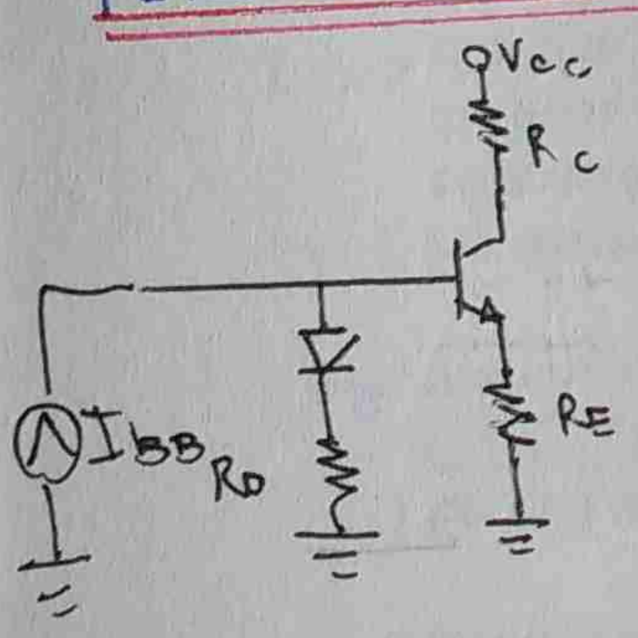
$$S_\beta = \frac{\Delta I_{CQ1}}{\beta_1}\frac{R_B + R_E}{R_B + (\beta_2 + 1) R_E}$$

Si $R_E \to 0$ $I_{CQ} \to \infty$

$R_E \to \infty (M\Omega)$ $I_{CQ} \to 0$ Poca ganancia

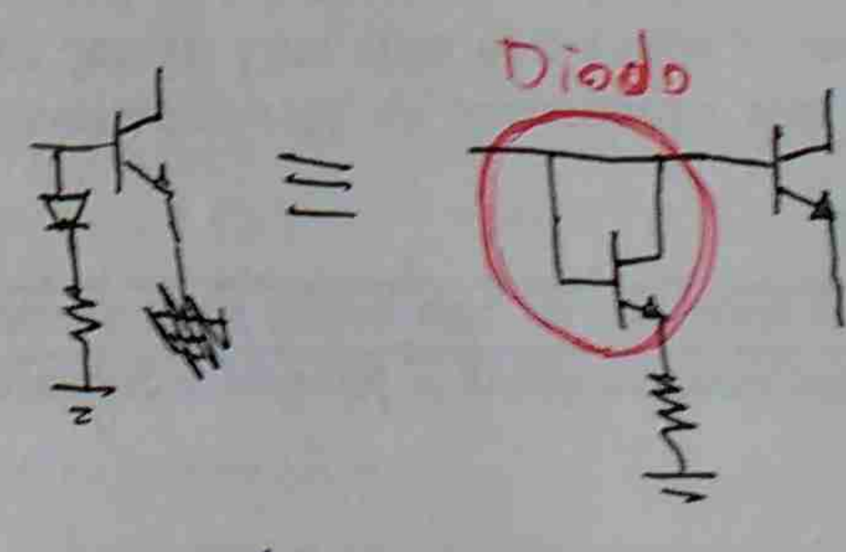
Para solucionar esto se recurre a la polarización por diodo.

Polarización por diodo



$$\frac{\Delta V_D}{\Delta T} = \frac{\Delta V_{BE}}{\Delta T}$$

siempre que el diodo y el trans sean del mismo material



C/S_V (factor estabilidad)

$$\frac{\Delta I_{CQ}}{\Delta T} = \frac{K}{R_E}$$

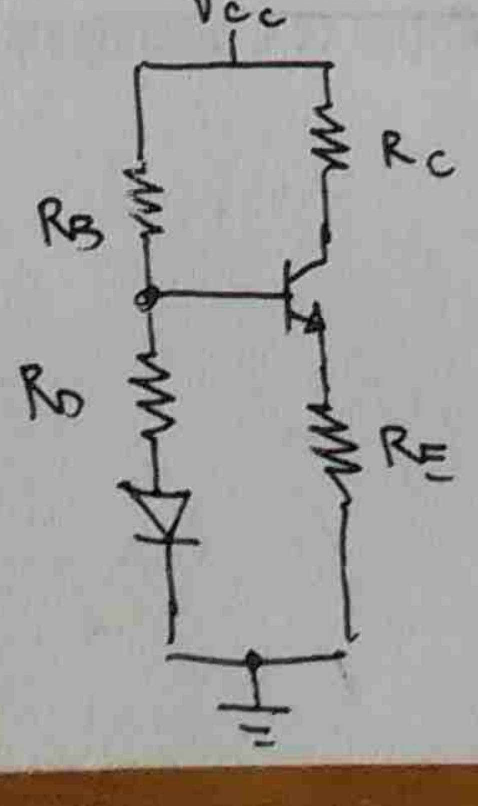
C/diodo (ideal)

$$\frac{\Delta I_{CQ}}{\Delta T} = 0$$

C/diodo Real

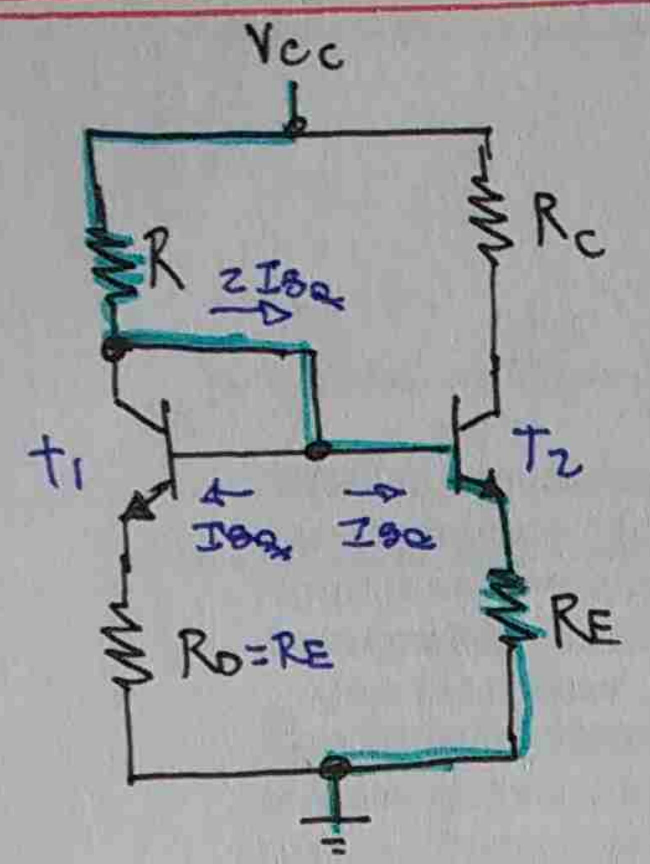
$$\frac{\Delta I_{CQ}}{\Delta T} = \frac{K}{R_E} + \frac{1}{1 + \frac{R_B}{R_D}}$$

Si necesito un $R_E = 10K$, lo logro con R_D y R_B (sinó I_{CQ} disminuye)



$$I_{CQ} = \frac{(V_{CC} - V_{BE})\, R_D}{R_E\,(R_B + R_D)}$$

Polarización Balanceada (Espejo de corriente)



LKT

$$V_{CC} = \left(I_{CQ} + \frac{2 I_{CQ}}{\beta}\right) R + V_{BE} + I_{CQ} R_E = I_{CQ}\left(1+\frac{2}{\beta}\right) R + V_{BE} + I_{CQ} R_E$$

$$V_{CC} = I_{CQ}\left[\left(\frac{\beta+2}{\beta}\right) R + R_E\right] + V_{BE}$$

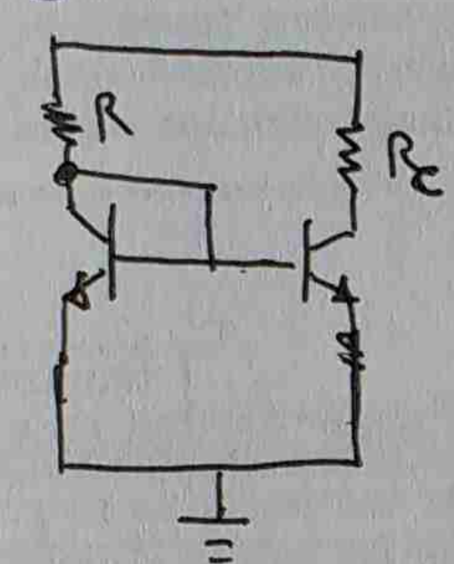
Si $\beta >> 2$

$$\boxed{I_{CQ} = \frac{V_{cc} - V_{be}}{R + R_e}}$$

Se llama espejo de corriente porque V_B es el mismo y I_{B1} e I_{B2} son iguales

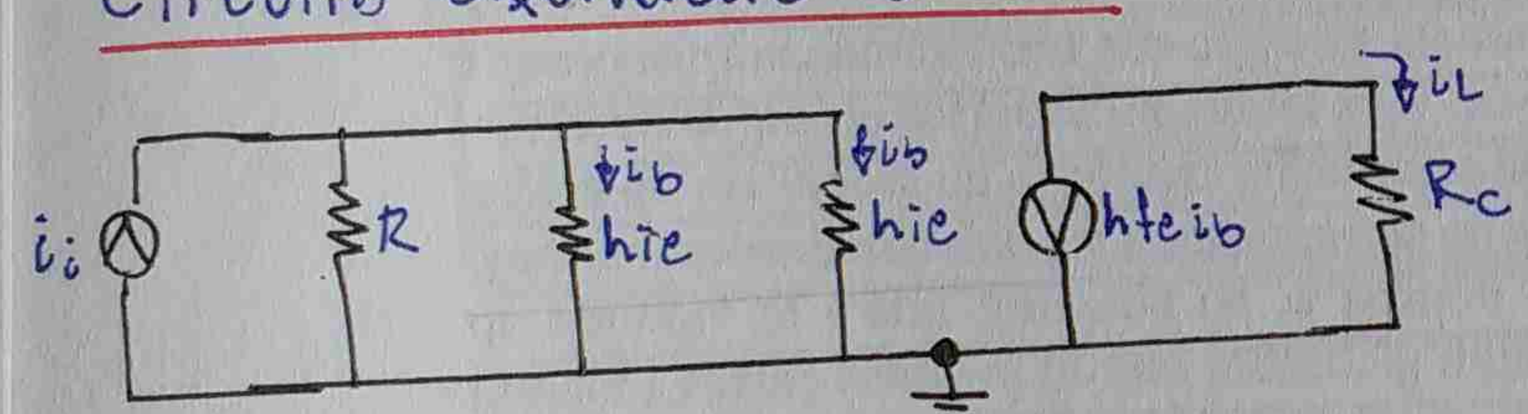
Para circuitos integrados

$R_d = R_E = 0$



$$I_{CQ} = \frac{V_{cc} - V_{be}}{R}$$

Circuito equivalente de CA



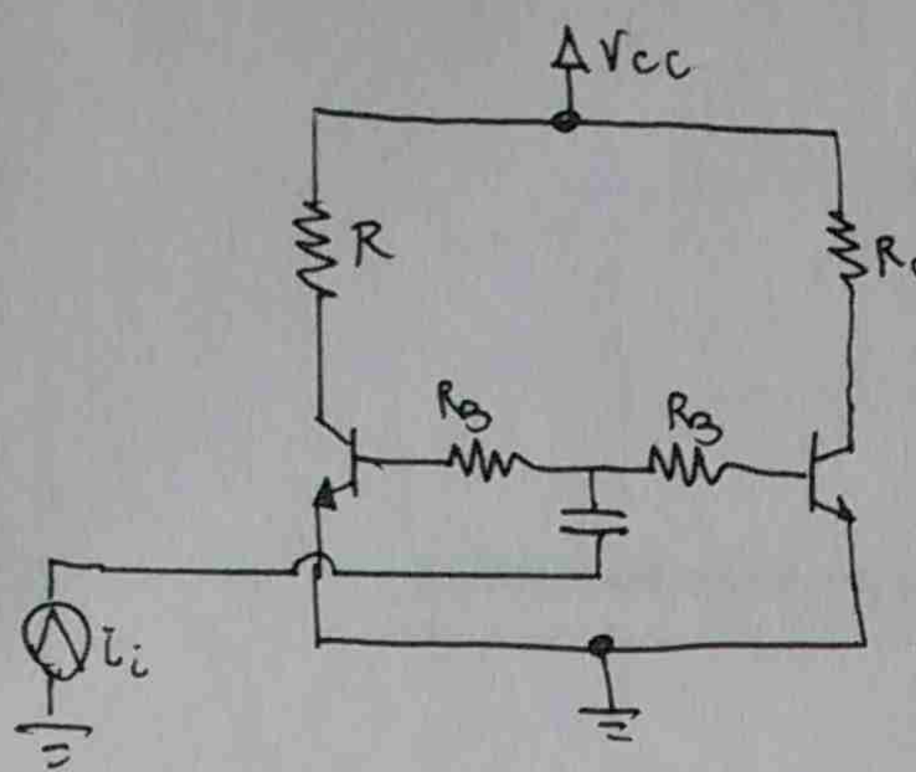
$i_L = h_{fe} \cdot i_b$

Si $R >> h_{ie}$

$i_i = 2 i_b$

$i_b = \frac{i_i}{2}$

$$A_i = \frac{i_L}{i_i} = \frac{i_L}{i_b}\frac{i_b}{i_i} = h_{fe}\frac{1}{2} = \frac{h_{fe}}{2}$$



$$V_{cc} = \left(I_{CQ} + \frac{2 I_{CQ}}{\beta}\right) R + \frac{I_{CQ}}{\beta} R_b + V_{be}$$

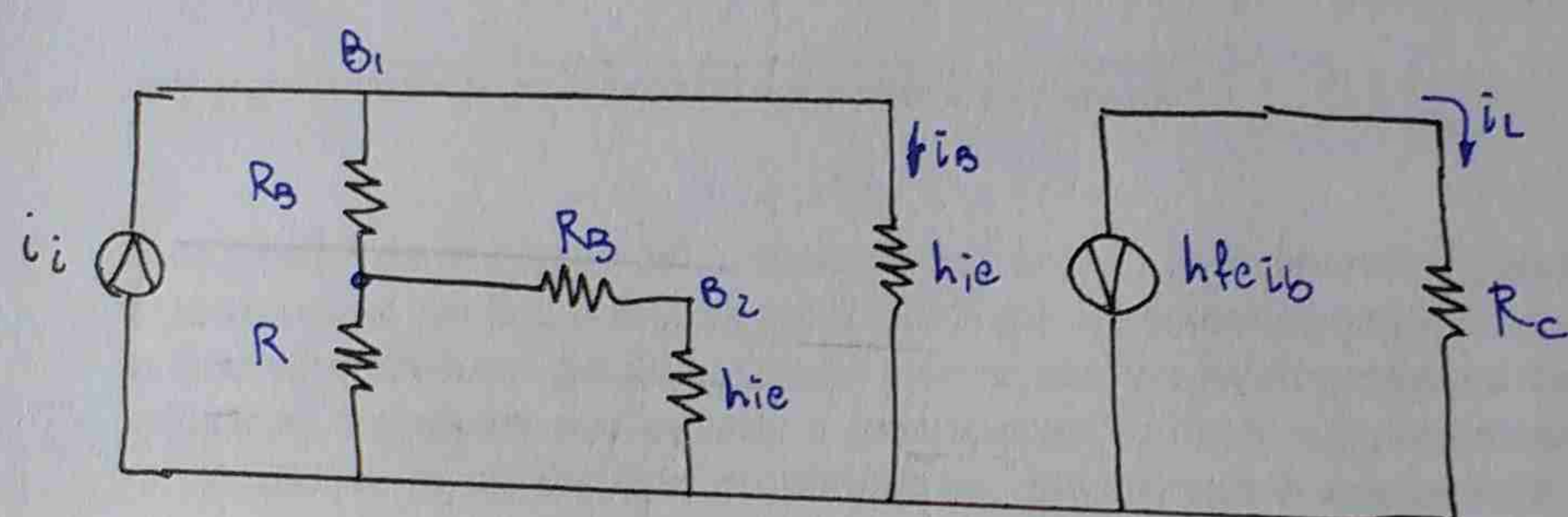
$$V_{cc} - V_{be} = I_{CQ}\left[\left(1 + \frac{2}{\beta}\right) R + \frac{R_b}{\beta}\right]$$

$$I_{CQ} = \frac{V_{cc} - V_{BE}}{\frac{\beta+2}{\beta} R + \frac{R_B}{\beta}}$$

Si: $\frac{R_B}{\beta} << R$

$$I_{CQ} = \frac{V_{cc} - V_{BE}}{R}$$

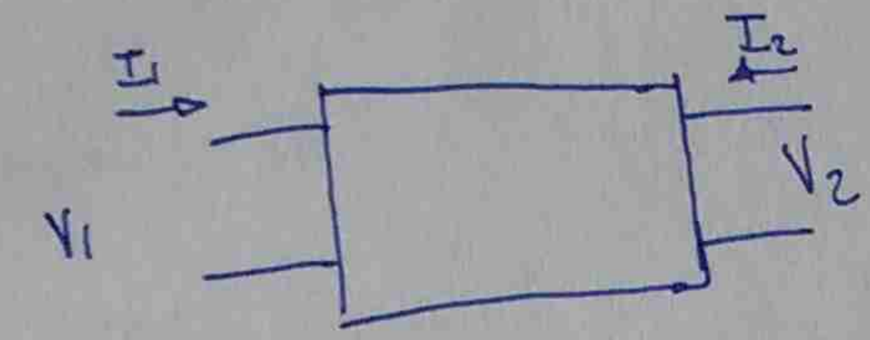
$\boxed{\text{La ganancia es el doble del Anterior}}$



Si $R_B >> h_{ie}$

$$A_i = \frac{i_L}{i_i} = \frac{i_L}{i_b} \cdot \frac{i_b}{i_i} = h_{fe} = 100$$

Parametros Híbridos



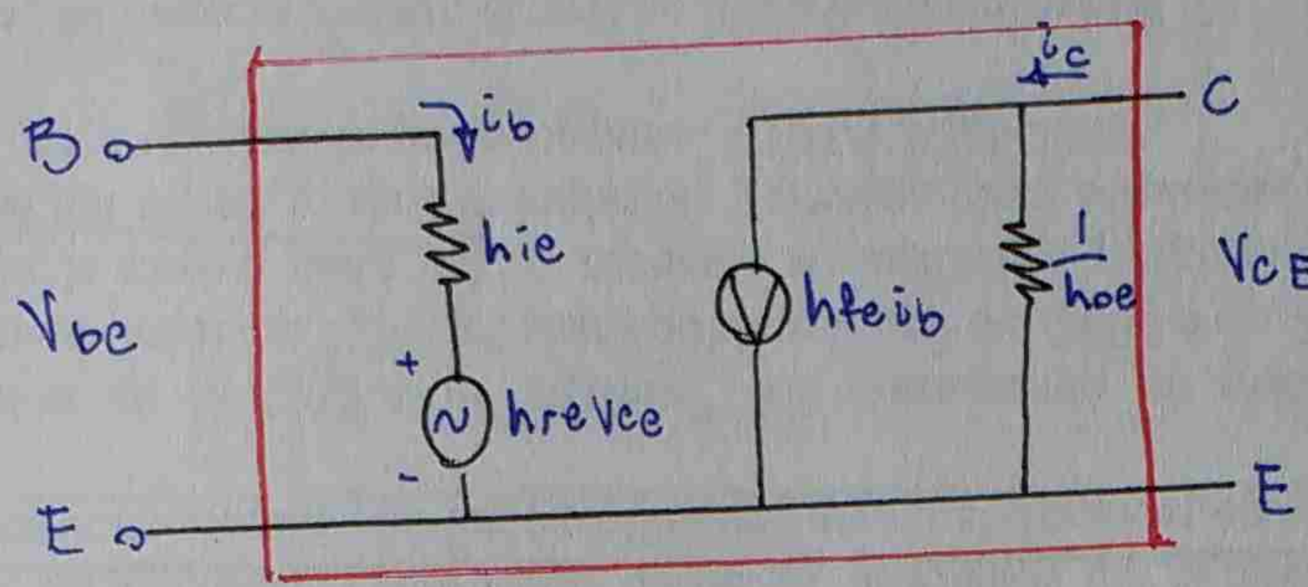
$$v_1 = h_{11} i_1 + h_{12} v_2$$

$$i_2 = h_{21} i_1 + h_{22} v_2$$

$$v_1 = h_i i_1 + h_r v_2$$

$$i_2 = h_f i_1 + h_o v_2$$

$$\begin{bmatrix} h_i & h_r \\ h_f & h_o \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} V_1 \\ I_2 \end{bmatrix}$$



$$\boxed{h_{ie} = \frac{25mV}{I_{CQ}} h_{fe}}$$

Fórmula no convencional de calcular I_{CQ}

$$\underbrace{h_{ie} << R_B}_{\text{Ganancia}} \overbrace{ << \beta R_E}^{\text{Estabilidad}}$$

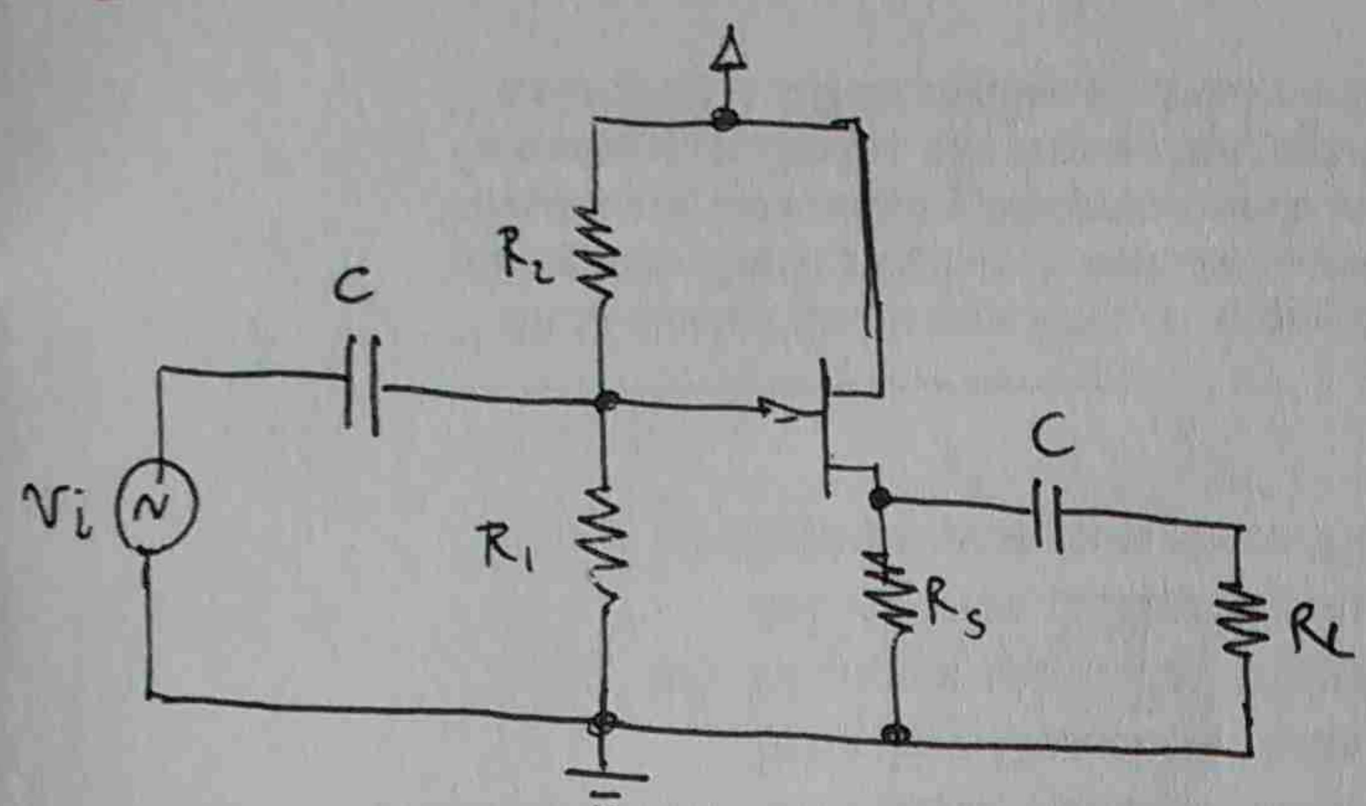
En Base Común

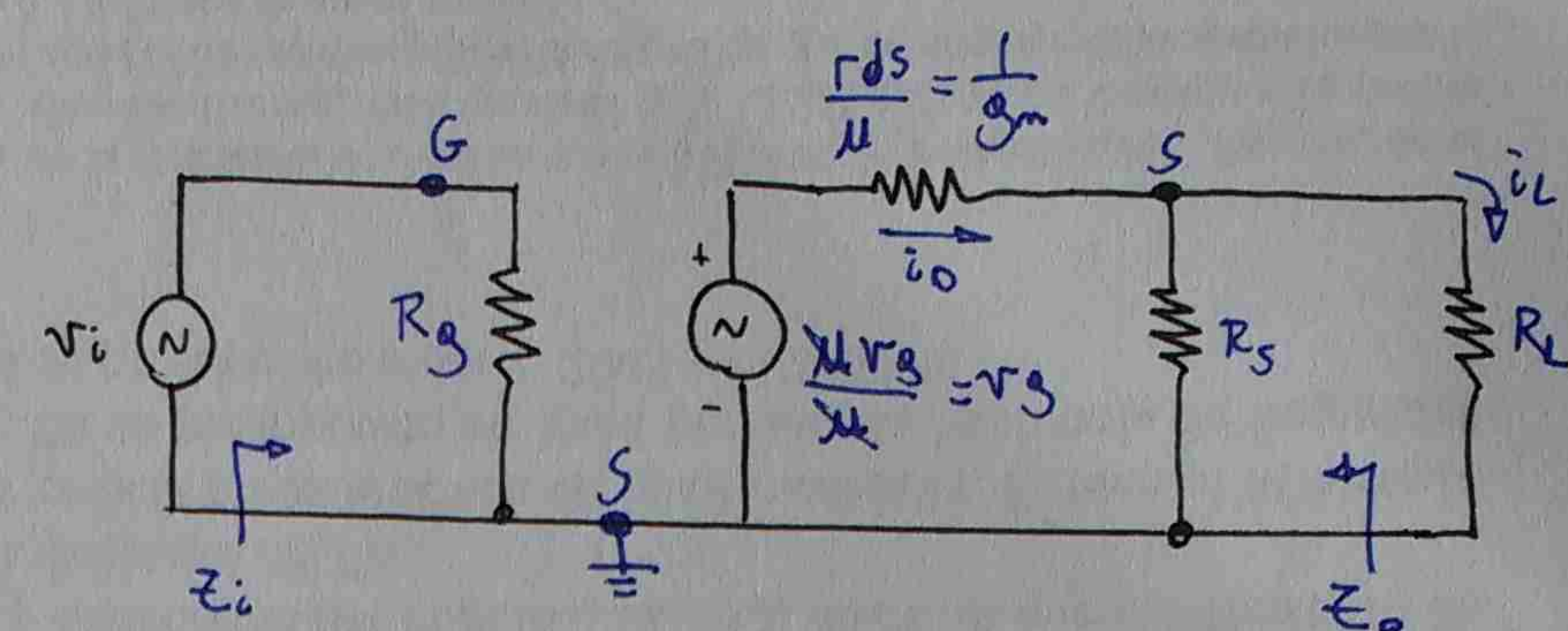
$$\boxed{h_{ib} = \frac{h_{ie}}{h_{fe}+1}} \quad \boxed{h_{rb} \to 0} \quad \boxed{h_{fb} = \frac{h_{fe}}{h_{fe}+1} \simeq 1} \quad \boxed{h_{ob} = \frac{h_{oe}}{h_{fe}+1}}$$

Parámetros internos del FET

$r_{ds}\, g_m = \mu$

Drenador Común





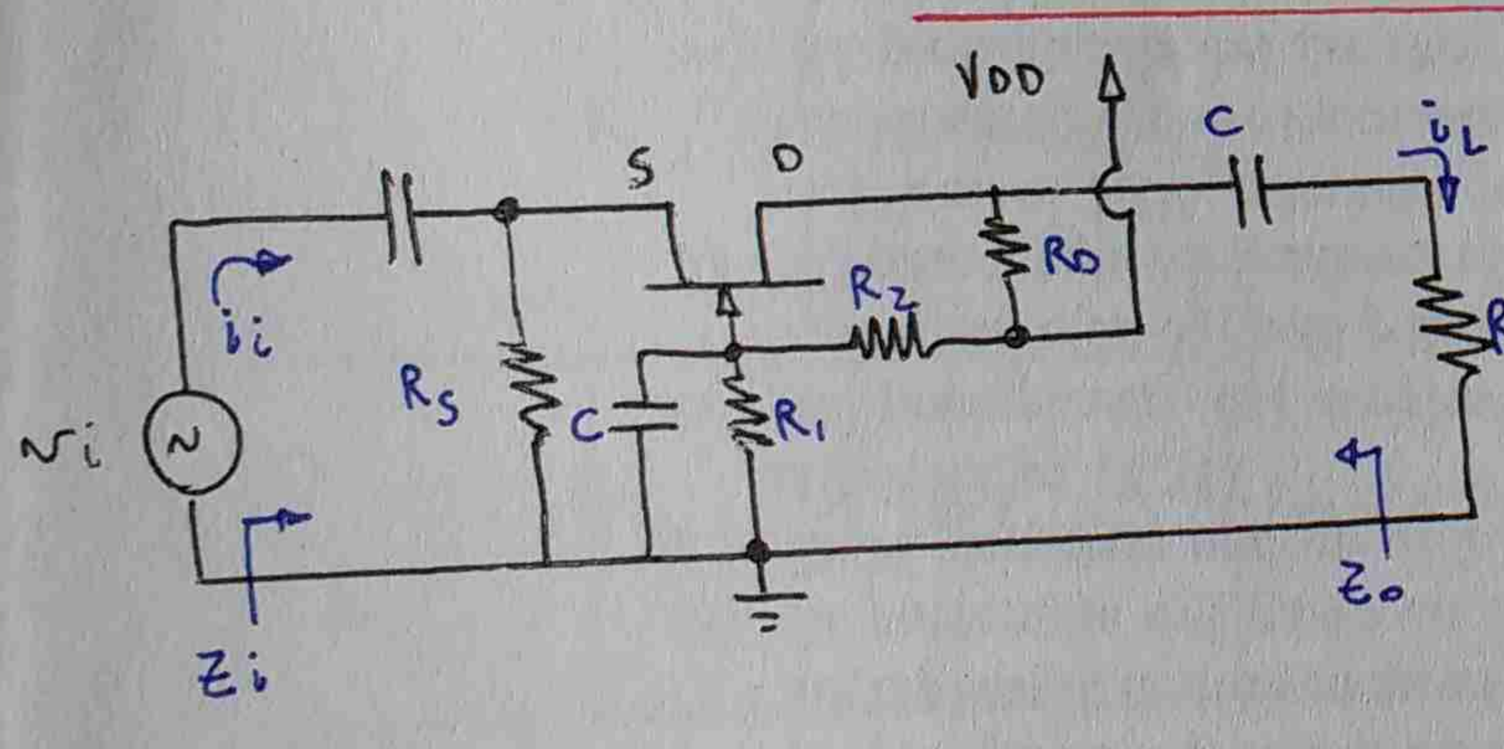
$Z_i = R_g$

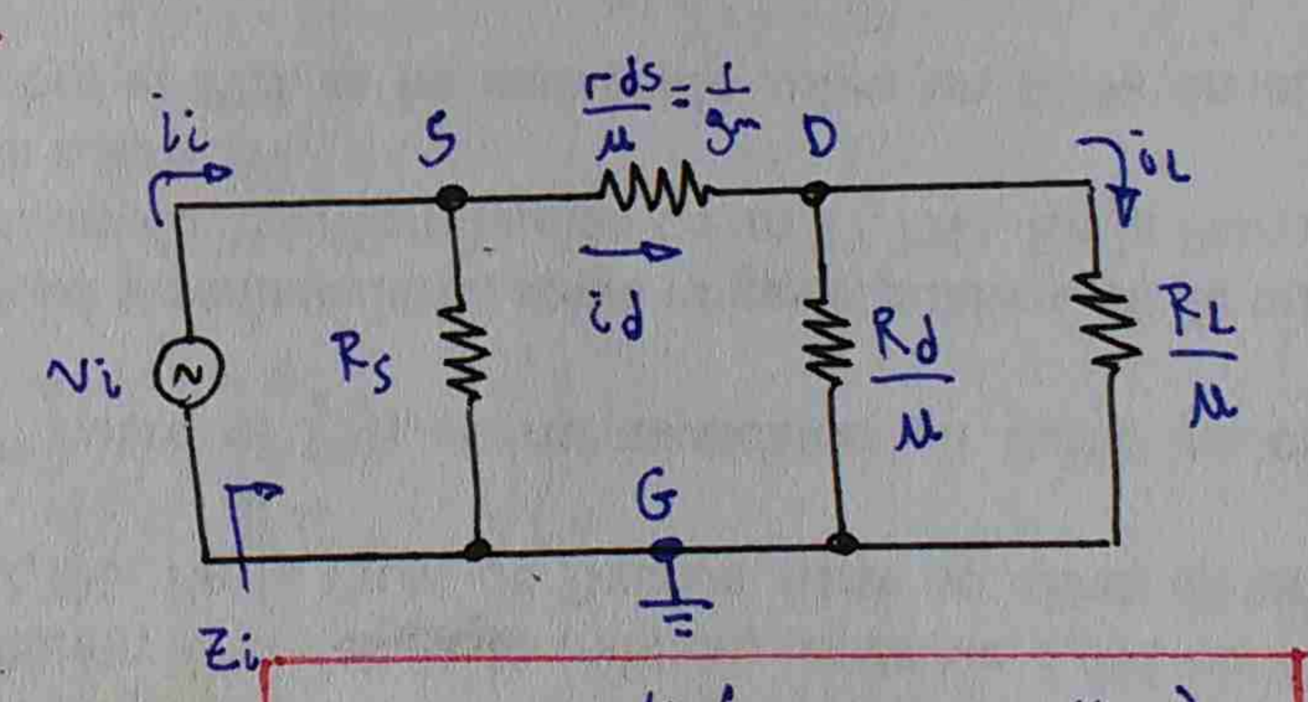
$Z_o = R_s // \frac{1}{g_m}$

$$A_v = \frac{v_L}{v_i} = \frac{v_L}{i_d} \cdot \frac{i_d}{v_g} \cdot \frac{v_g}{v_i} = R_s//R_L \quad \frac{1}{\frac{r_{ds}}{\mu} + R_s//R_L}$$

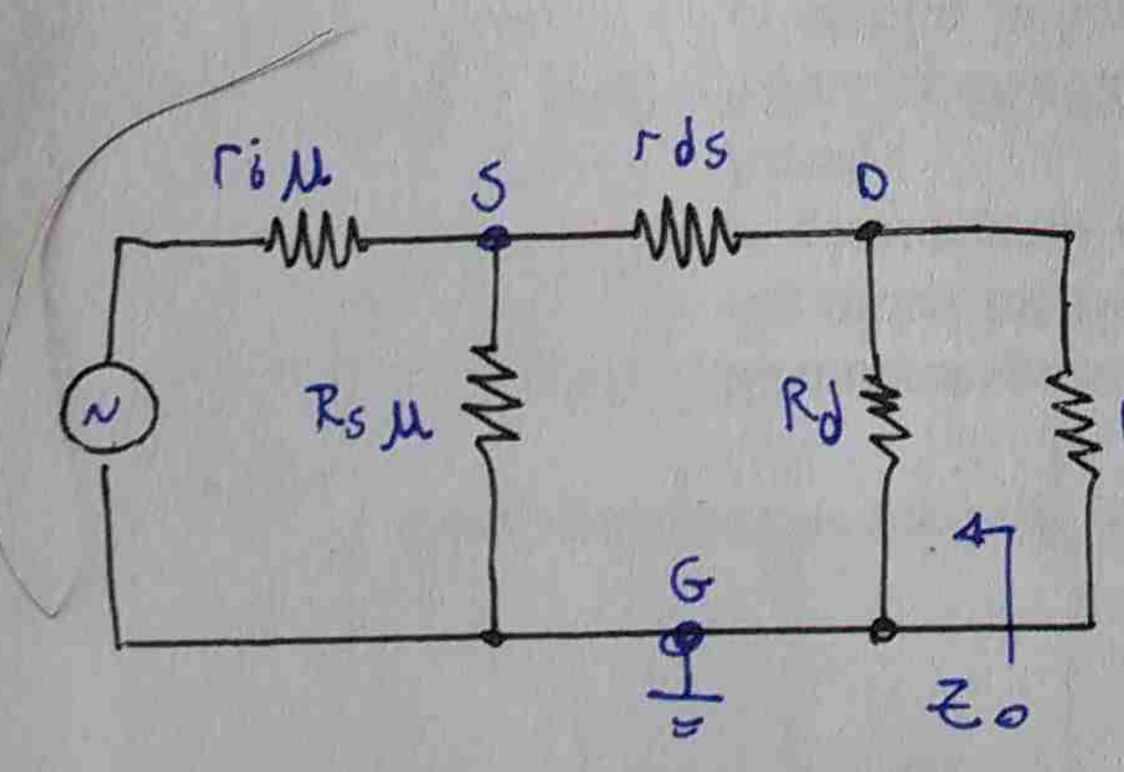
$$A_i = A_v \frac{Z_i}{R_L} = \frac{R_s}{R_s + R_L} \quad \frac{1}{\frac{1}{g_m} + R_s//R_L} \, R_g$$

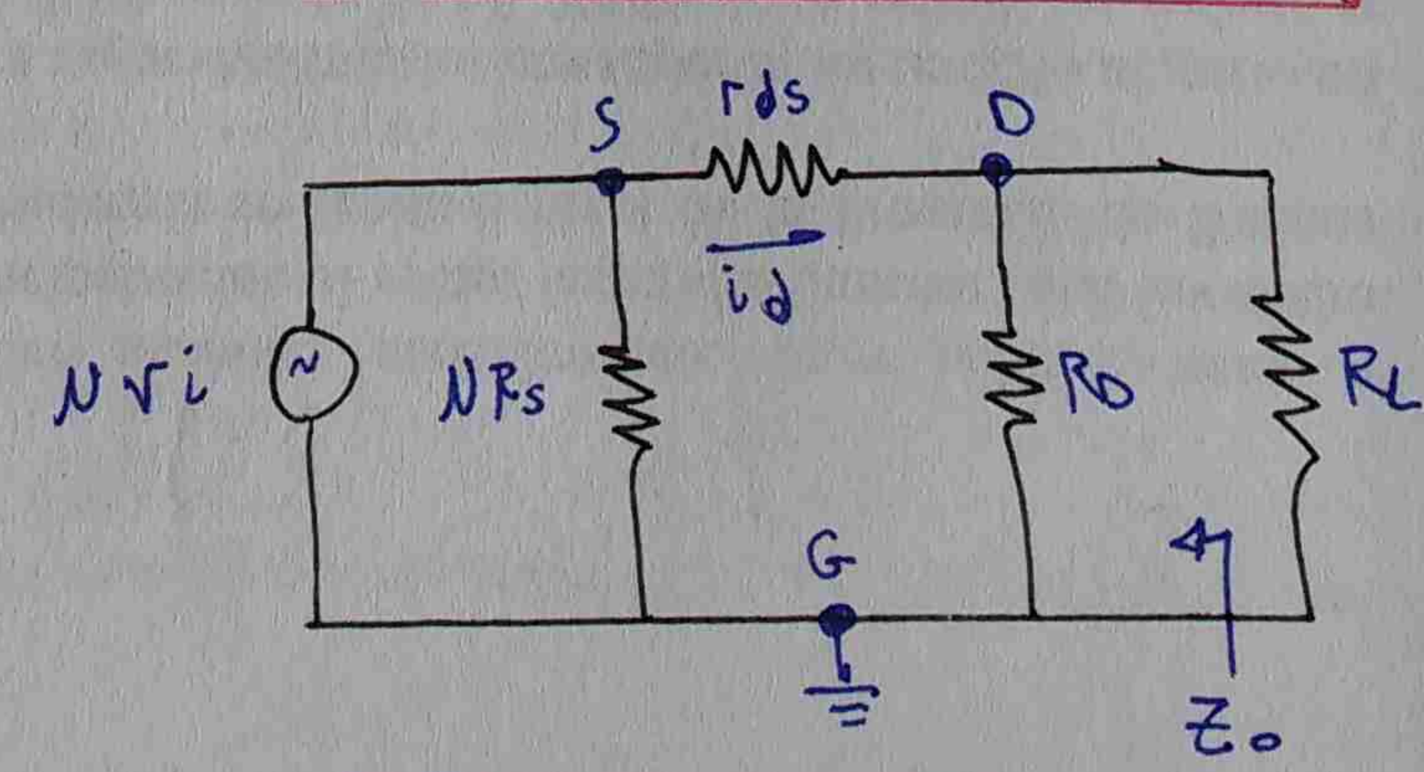
Compuerta Común





$$\boxed{Z_i = R_s // \left(\frac{r_{ds} + R_d//R_L}{\mu}\right)}$$





$$\boxed{Z_o = R_d // \left[r_{ds} + (r_i // R_s)\mu\right]}$$

$$\boxed{Z_o = R_D // r_{ds}}$$

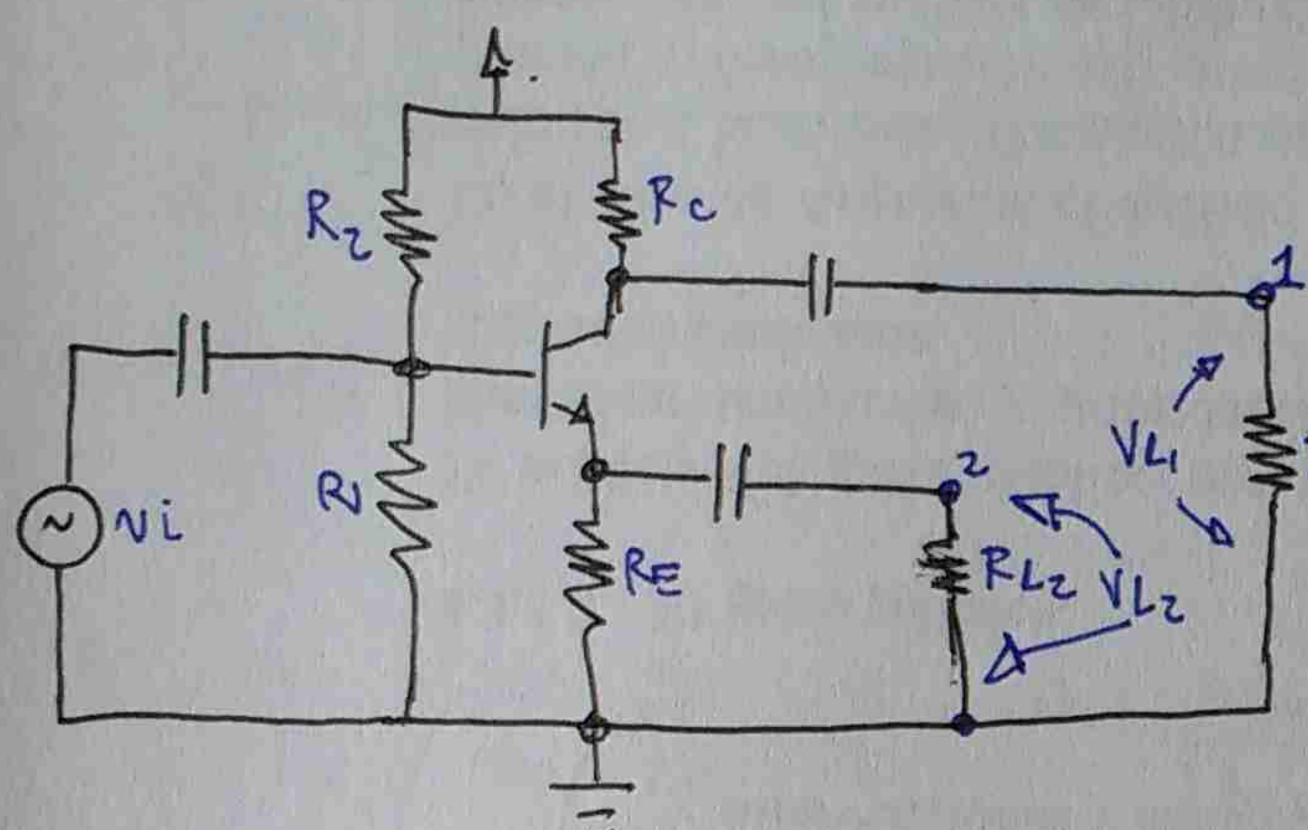
Con $R_i \neq 0$

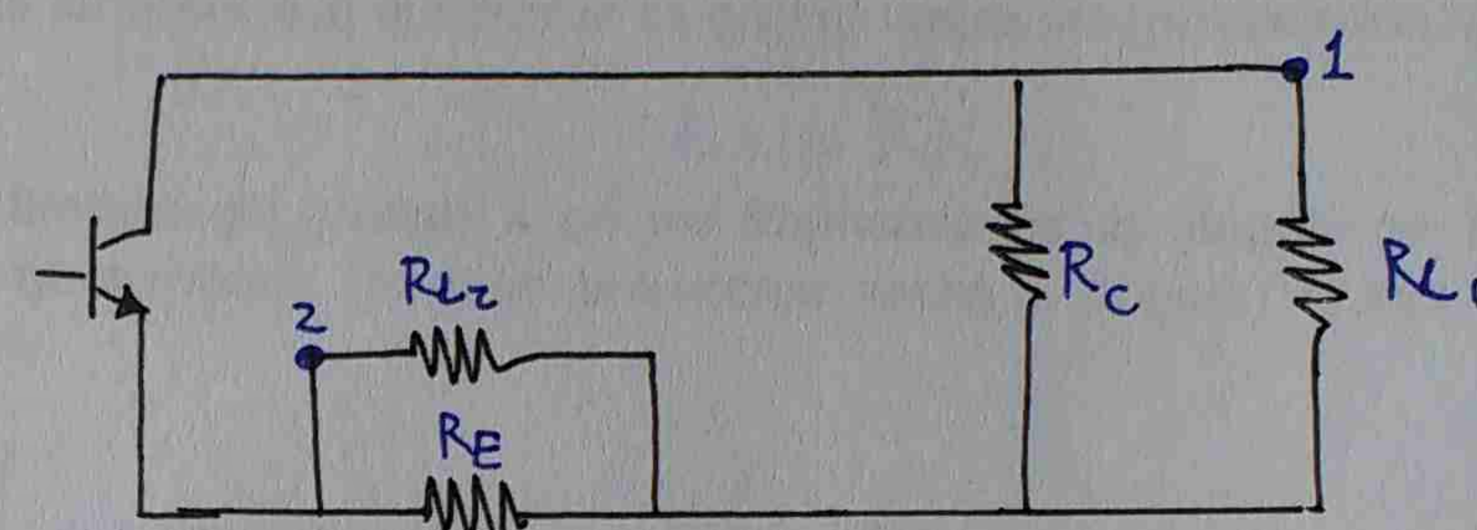
$$A_i = \frac{i_L}{i_i} = \frac{i_L}{i_d}\,\frac{i_d}{i_i} = \frac{R_d}{R_d + R_L}\;\frac{\mu R_s}{\mu R_s + r_{ds} + R_d /\!/ R_L}$$

$$A_v = A_i \frac{R_L}{Z_i} = (R_d /\!/ R_L)\,\frac{\mu \cancel{R_s}}{\cancel{\mu R_s + r_{ds} + R_d /\!/ R_L}} \cdot \frac{1}{\dfrac{\cancel{R_s \mu}\,(r_{ds} + R_d /\!/ R_L)}{\cancel{\mu R_s + r_{ds} + R_d /\!/ R_L}} \cdot \dfrac{1}{\cancel{\mu}}}$$

$$\boxed{A_v = \frac{\mu\,(R_d /\!/ R_L)}{r_{ds} + R_d /\!/ R_L}}$$

Inversor de fase con Transistor Bipolar

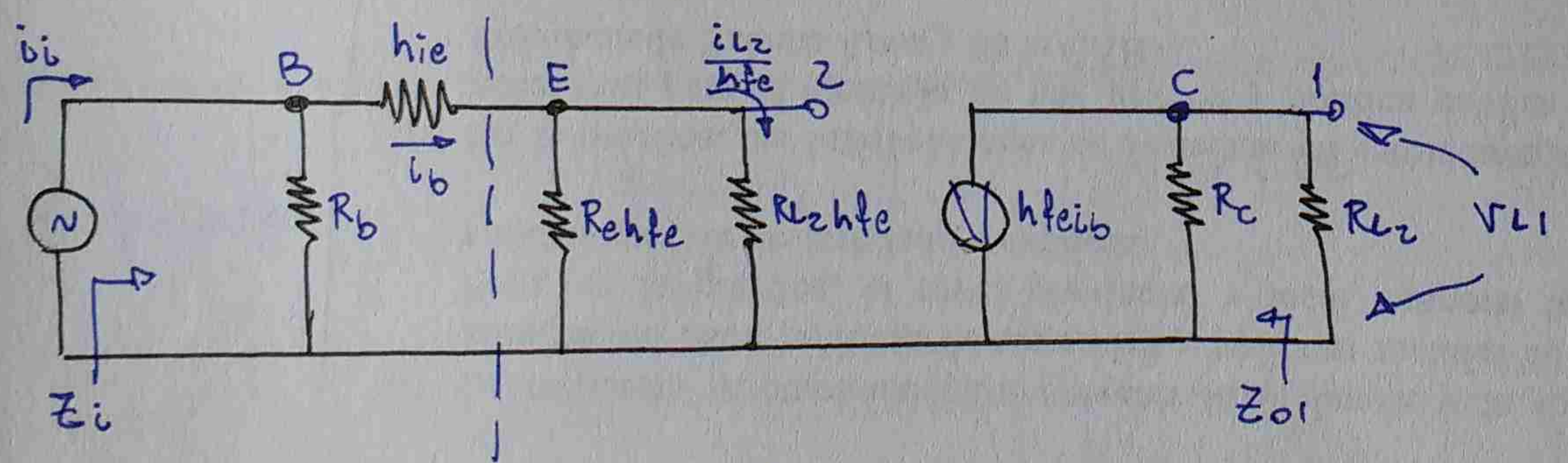




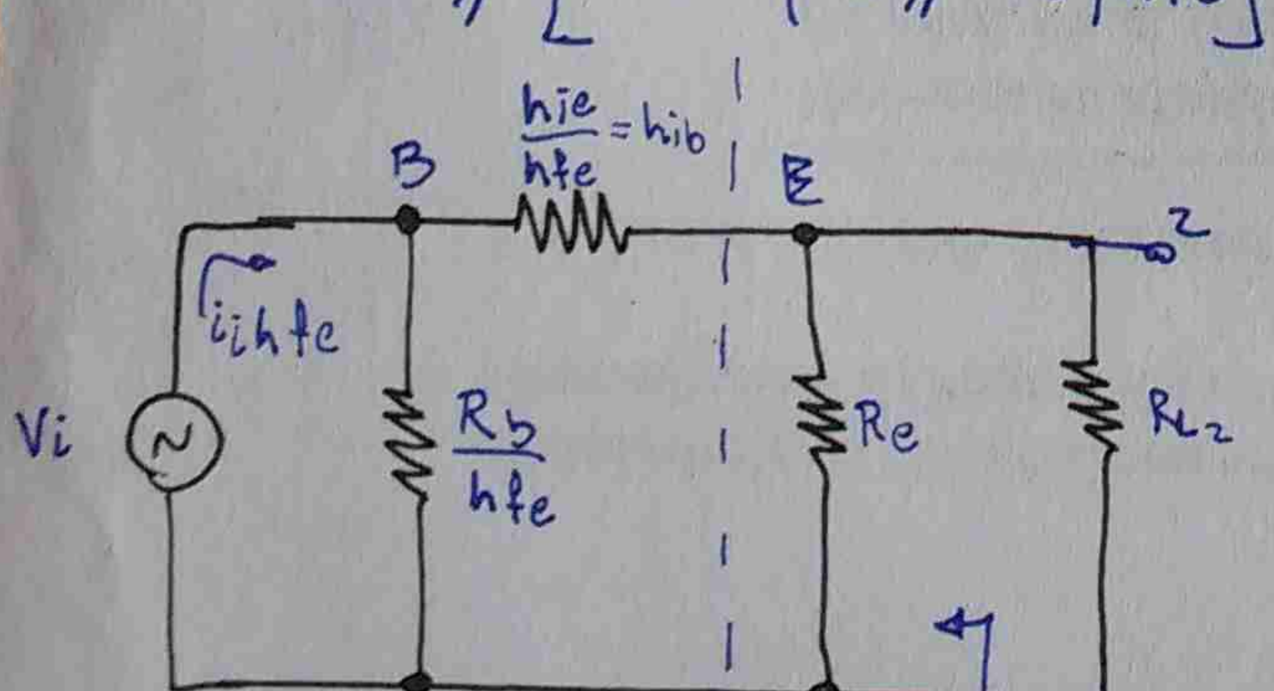
$$|V_{L1}| = |V_{L2}|$$

Condición de inversor de fase

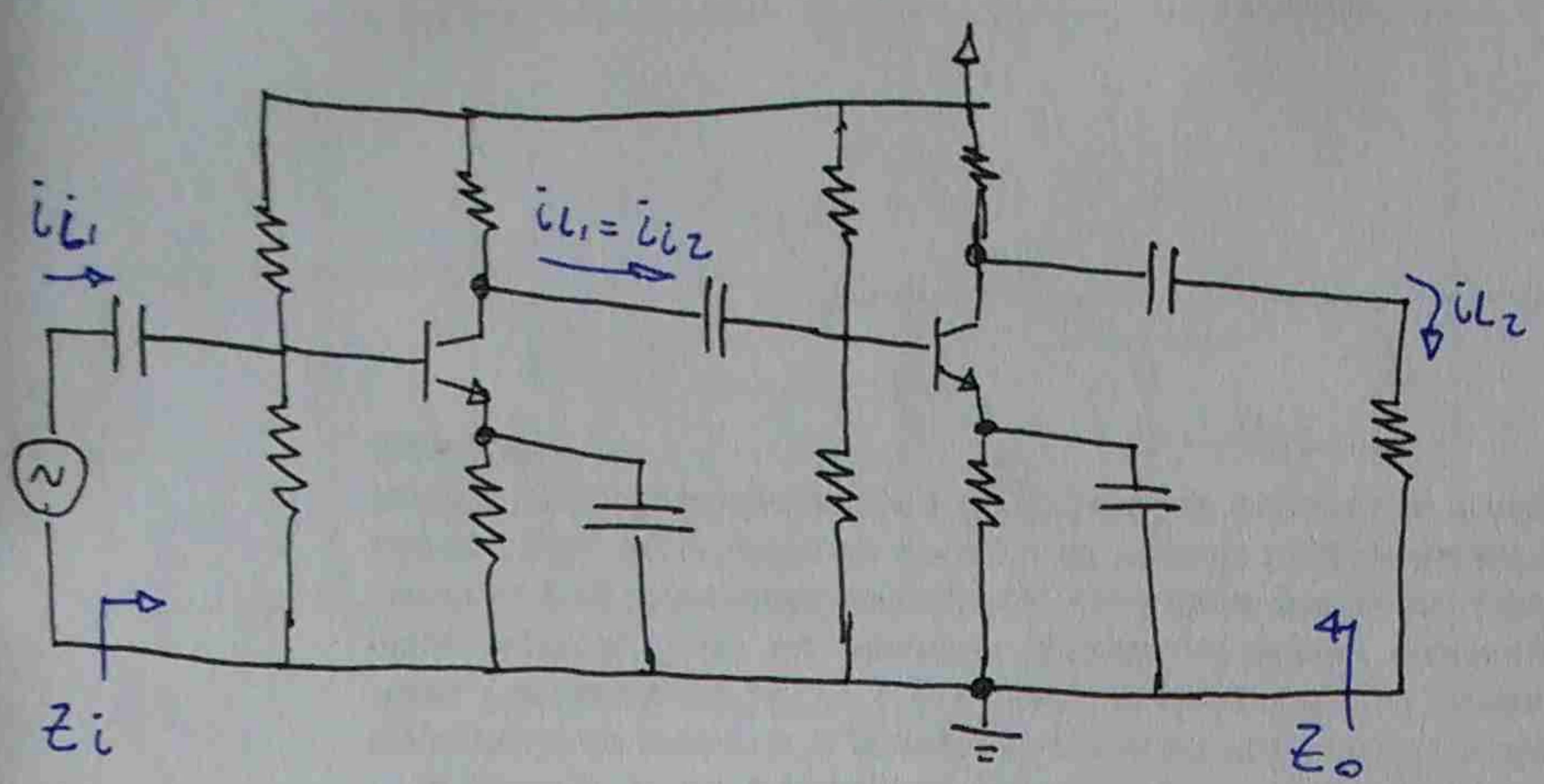
$$R_C /\!/ R_{L1} = R_{L2} /\!/ R_E$$



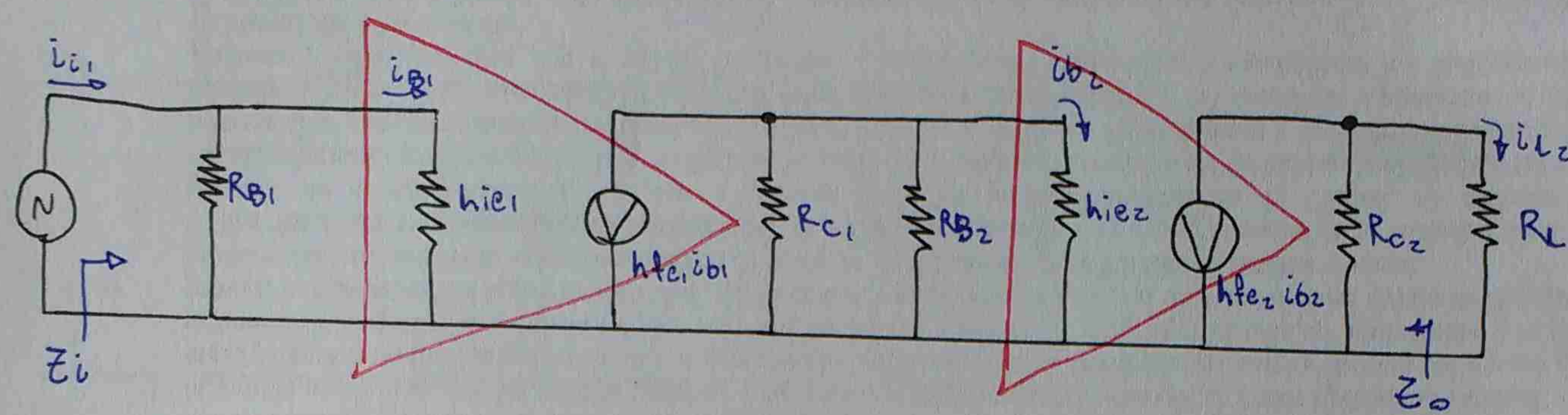
$$Z_i = R_b /\!/ \left[h_{ie} + (R_e /\!/ R_{L2})\,h_{fe}\right] \qquad Z_{o1} = R_C$$



Amplificadores Multietapa:



EC - EC.



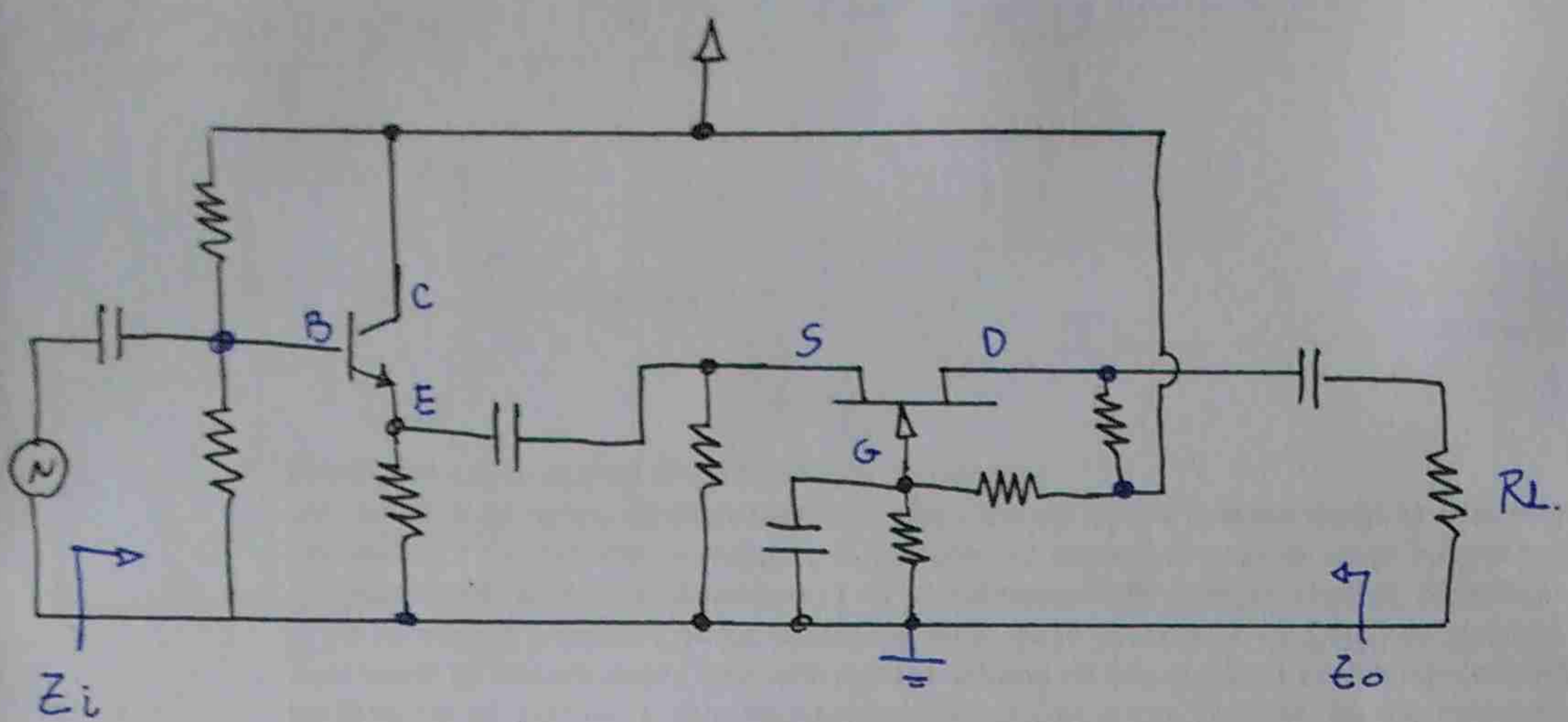
$Z_i = R_{B1} // h_{ie1}$

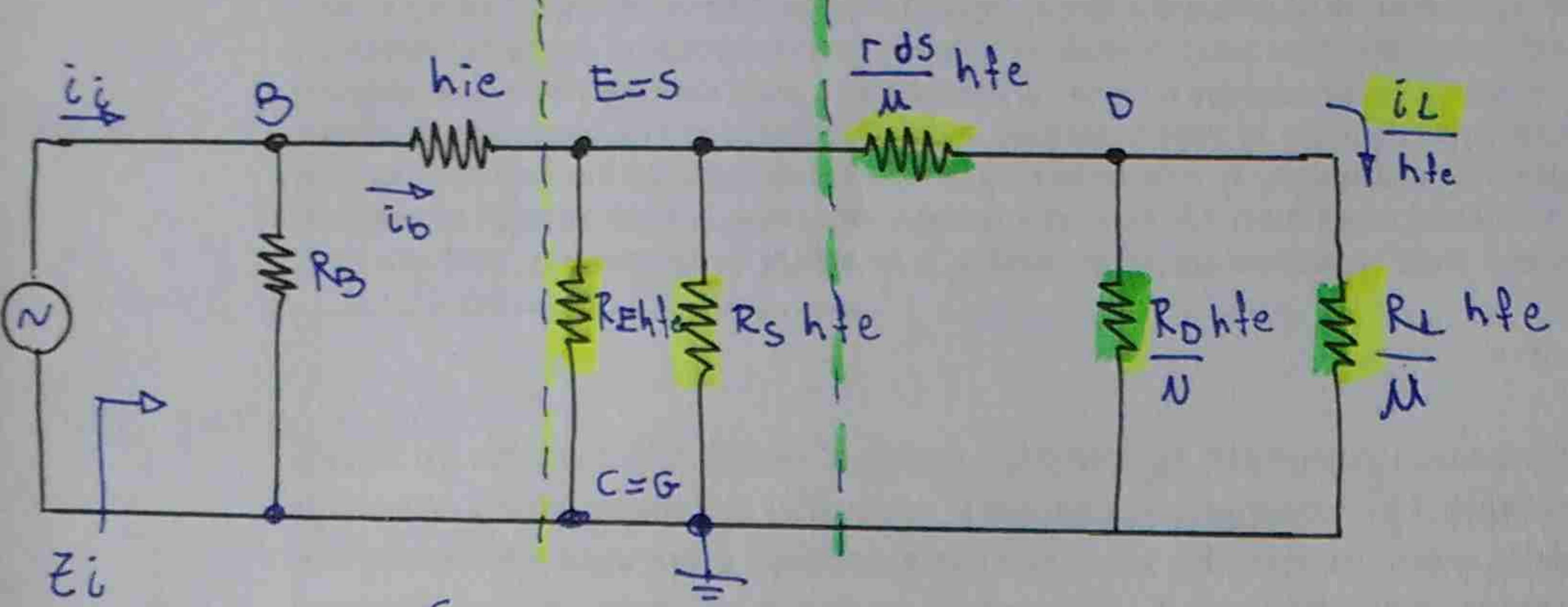
$Z_o = R_{C2}$

$$A_i = \frac{i_L}{i_i} = \frac{i_L}{i_{b2}} \cdot \frac{i_{b2}}{i_{b1}} \cdot \frac{i_{b1}}{i_i} = -h_{fe}\left(\frac{R_{C2}}{R_{C2}+R_L}\right)\left(-h_{fe}\,\frac{R_C // R_{B2}}{R_{C1} // R_{B2} + h_{ie2}}\right)\left(\frac{R_{b1}}{R_{b1}+h_{ie1}}\right)$$

$$A_v = A_i \frac{R_L}{Z_i}$$

Bipolares	E - B (h_{fe})	$v = cte$	$\Rightarrow$ $\uparrow i \downarrow$ $\downarrow R \uparrow$
FET	D - S (μ)	$i = cte$	$\Rightarrow$ $\uparrow \frac{V}{R} \downarrow$

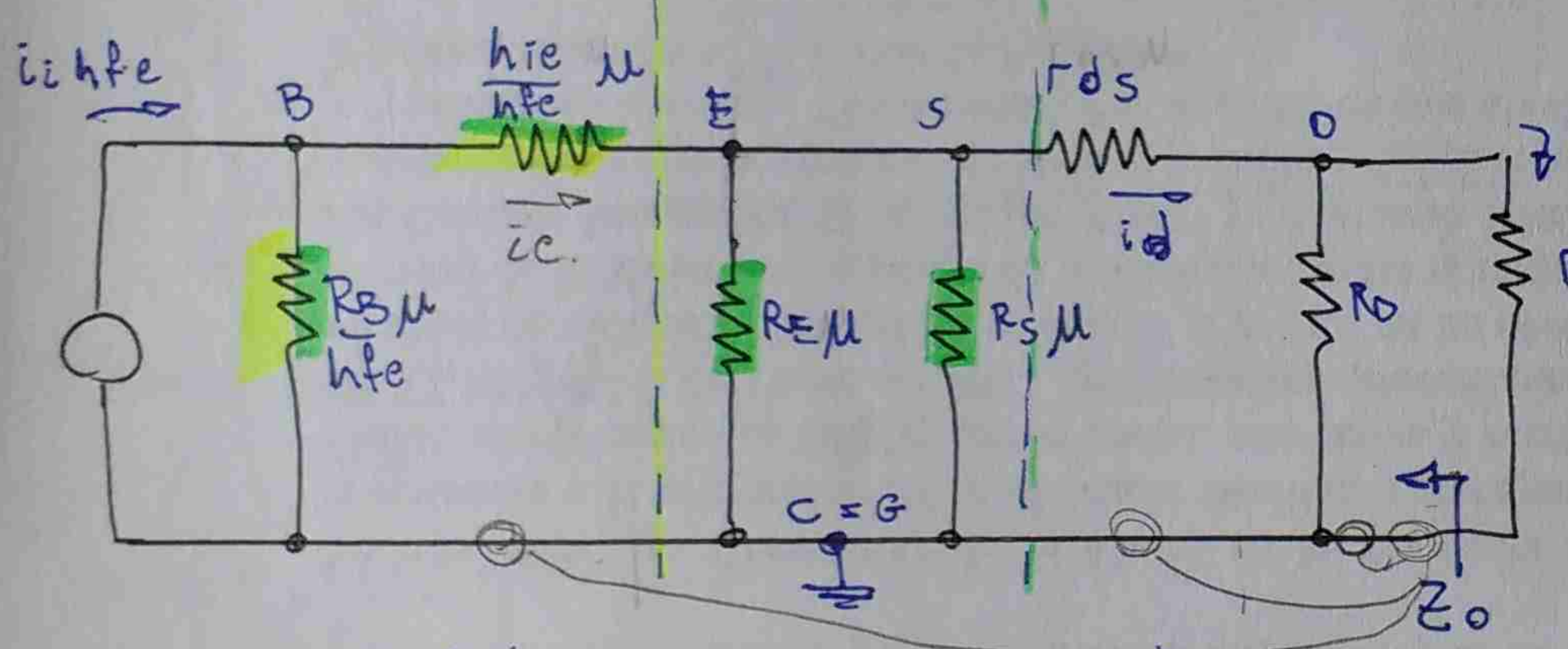




Bip. B−E v=cte ↑i R↓ ↓ ↑

FET S−D i=cte ↑ v/R ↓ ↑ ↓

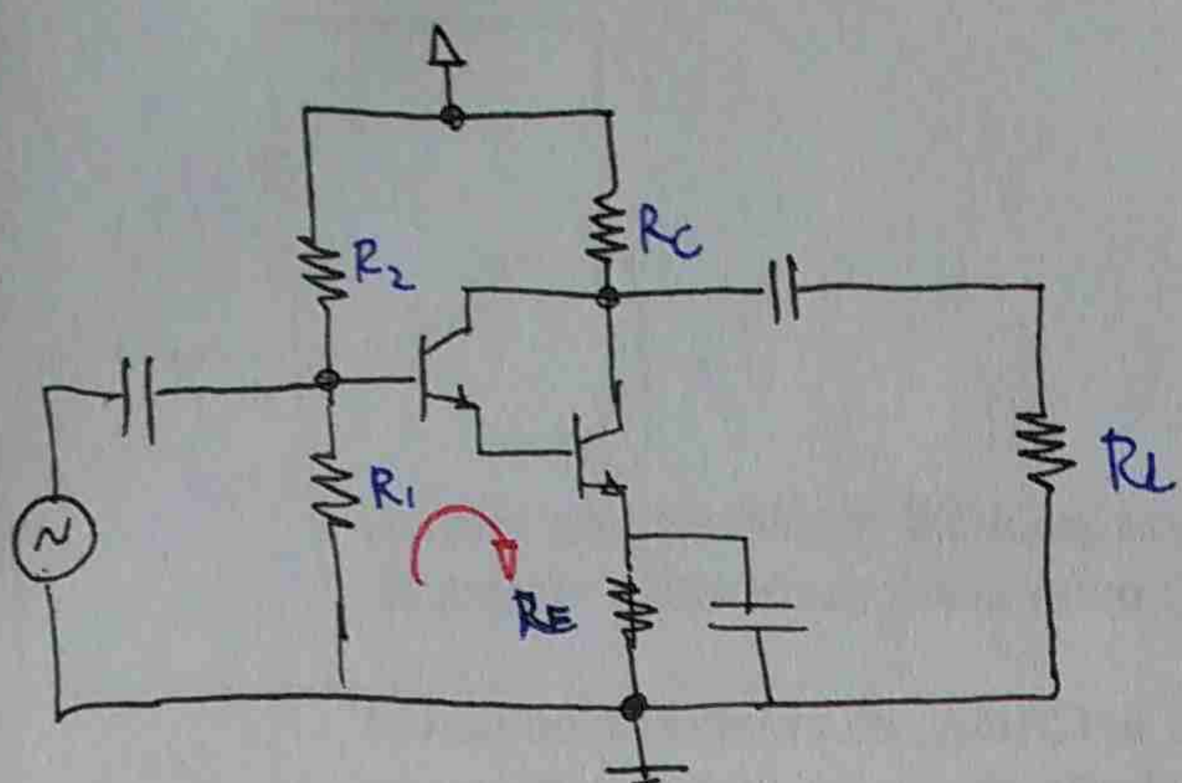
$$Z_i = R_b // \left\{ h_{ie} + (R_e // R_s) h_{fe} // \left[\left(\frac{r_{ds} + R_D // R_L}{\mu} \right) h_{fe} \right] \right\}$$



$$Z_o = R_D // \left\{ r_{ds} + \left[(R_E // R_s // h_{ib}) \mu \right] \right\}$$

$$A_i = \frac{i_L}{i_i} = \frac{i_L}{i_d} \frac{i_d}{i_e} \frac{i_e}{i_i} = \frac{R_D}{R_D + R_L} \frac{(R_E // R_s)\mu}{(R_E // R_s)\mu + r_{ds} + R_D // R_L} \left\{ h_{fe} \frac{\frac{R_b}{h_{fe}} \mu}{\left[\frac{R_B}{h_{fe}} \mu + h_{ib}\mu + (R_E // R_s)\mu \right] // \left[r_{ds} + (R_D // R_L) \right]} \right\}$$

Par Darlington PD y Par complementario



Kirchoff

$$I_{CQ2} = \frac{V_{BB} - 2V_{BE}}{\frac{R_B}{\beta^2} + R_E}$$

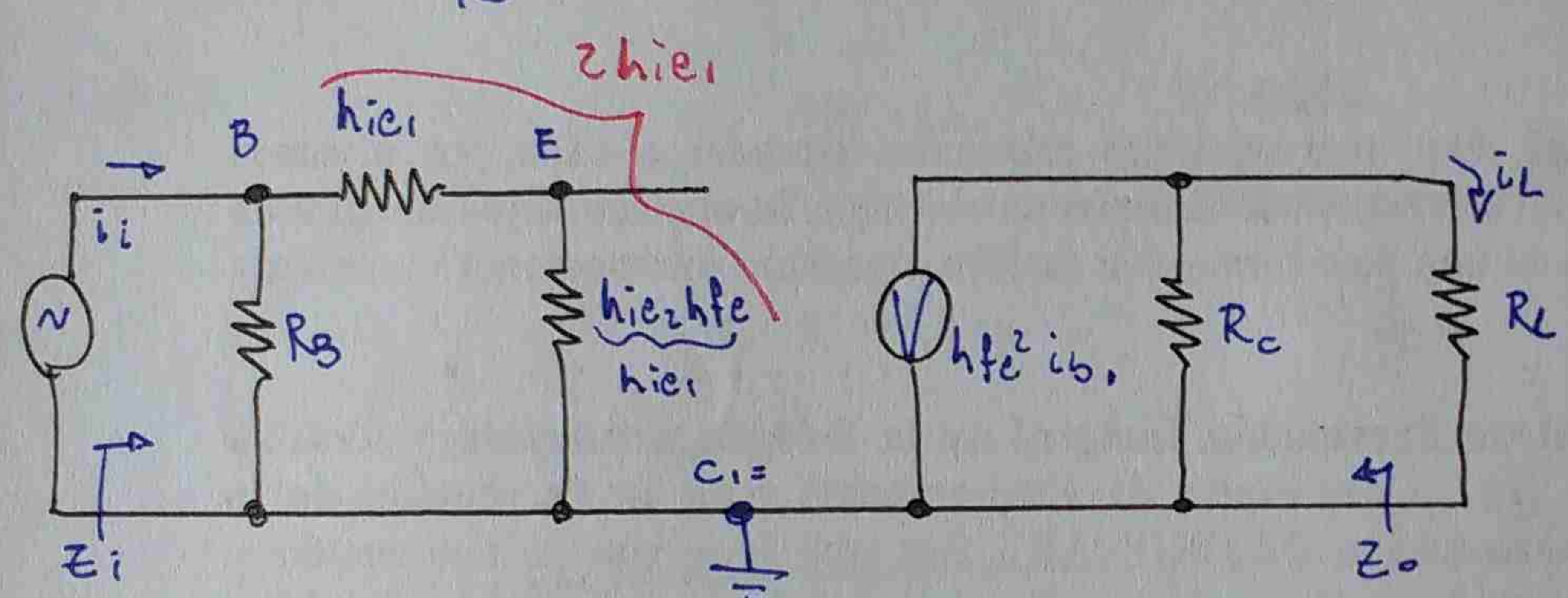
$$I_{BQ2} = \frac{I_{CQ2}}{\beta} \simeq I_{CQ1}$$

$$V_{CEQ2} = V_{CC} - I_{CQ2}(R_C + R_E)$$

$$V_{CEQ1} = V_{CEQ1} - V_{BE}$$

R_B para diseño

$$R_B = \frac{\beta^2 R_E}{10} \qquad V_{BB} = I_{CQ2}\left(\frac{R_B}{\beta^2} + R_E\right) + 2V_{BE}$$



si no existiera el capacitor de desacoplamiento por la rama que circula i_{b1} habría que sumarle $R_E h_{fe}^2$

$$Z_i = R_B // 2h_{ie1}$$

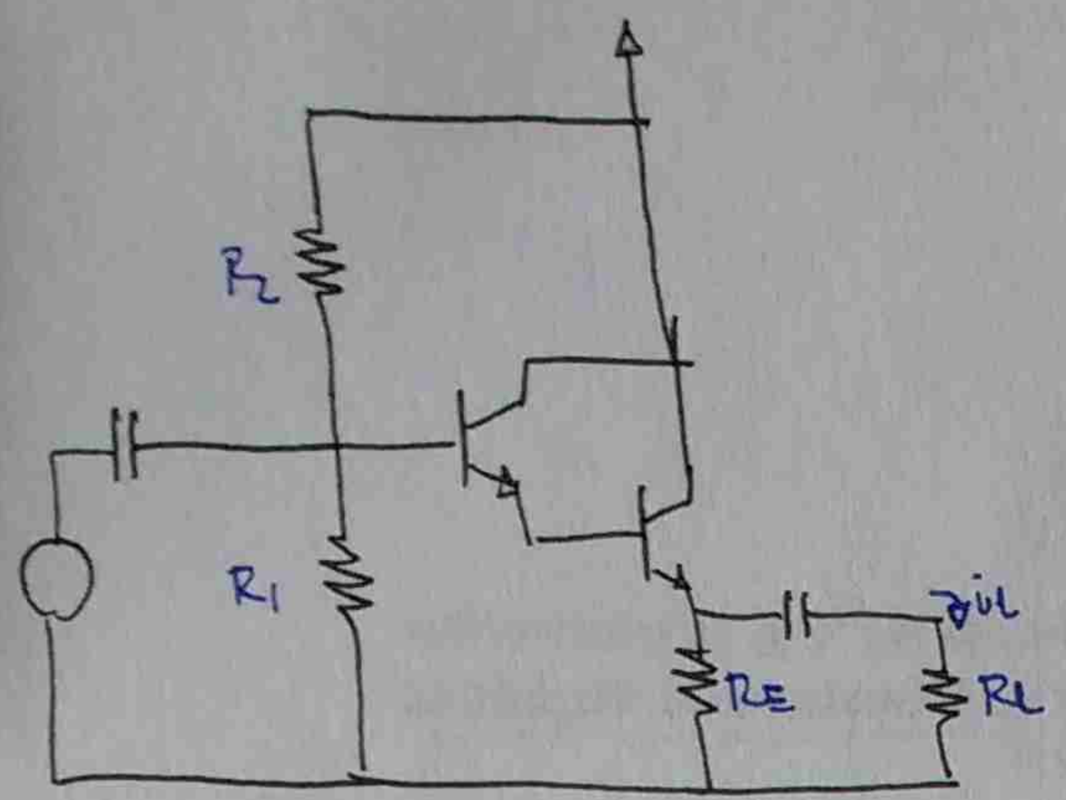
$$h_{ie1} = \frac{25\,mV}{I_{CQ1}} h_{fe}$$

$$h_{ie2} = \frac{25\,mV}{I_{CQ2}} \cancel{h_{fe}}$$

$$\boxed{Z_i = R_B // 2h_{ie1}}$$

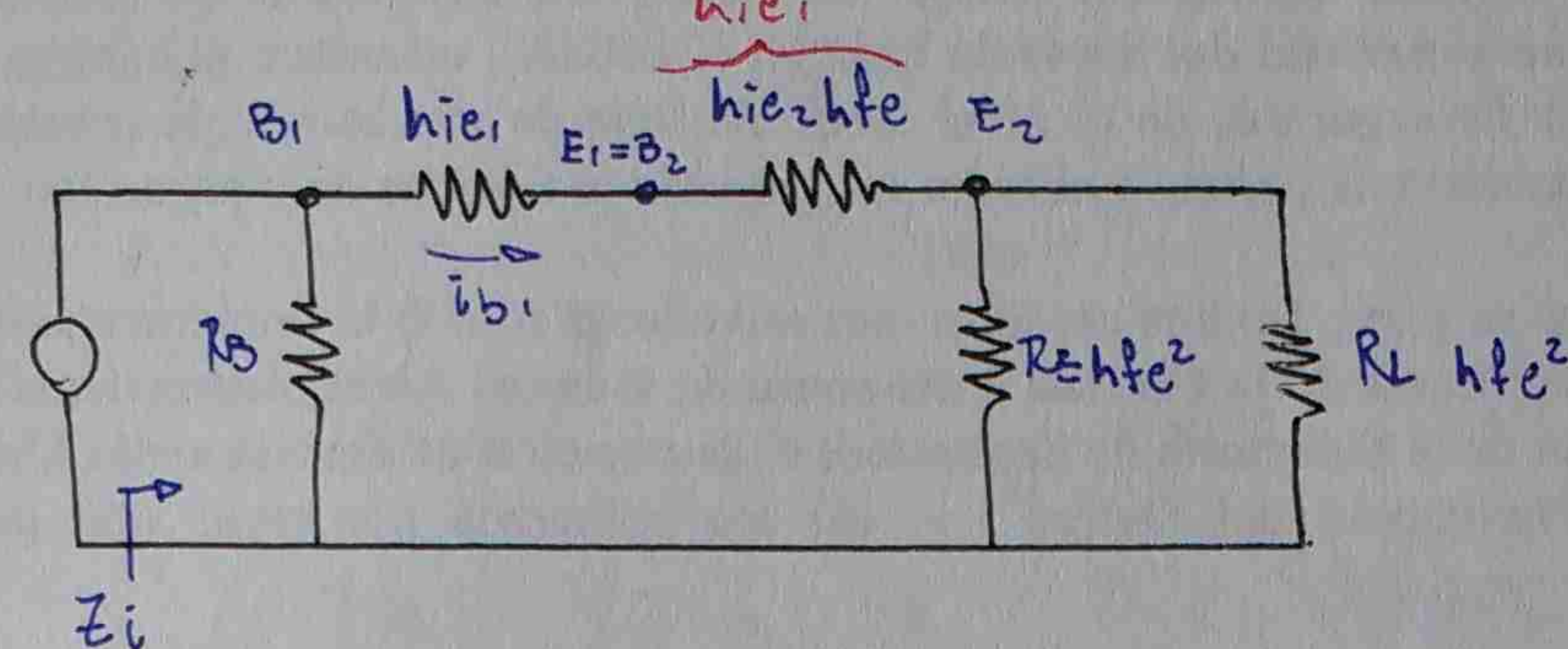
$$\boxed{Z_o = R_C}$$

$$A_i = -h_{fe}^2 \frac{R_C}{R_C + R_L} \cdot \frac{R_B}{R_B + 2h_{ie1}}$$



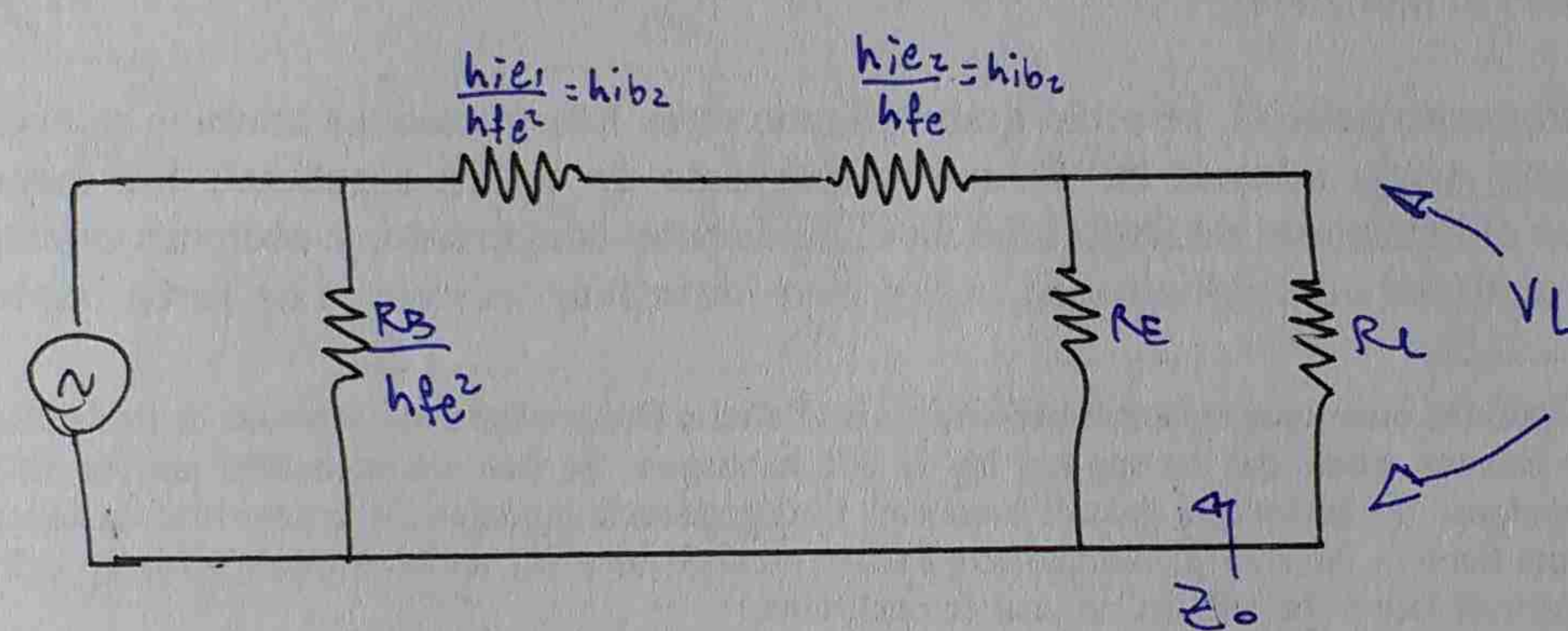
= CC = CC =

Entrada:



$$Z_i = R_B // \left[2h_{ie1} + (R_E//R_L)h_{fe}^2\right]$$

Salida



$$Z_o = R_E // 2h_{ib2}$$

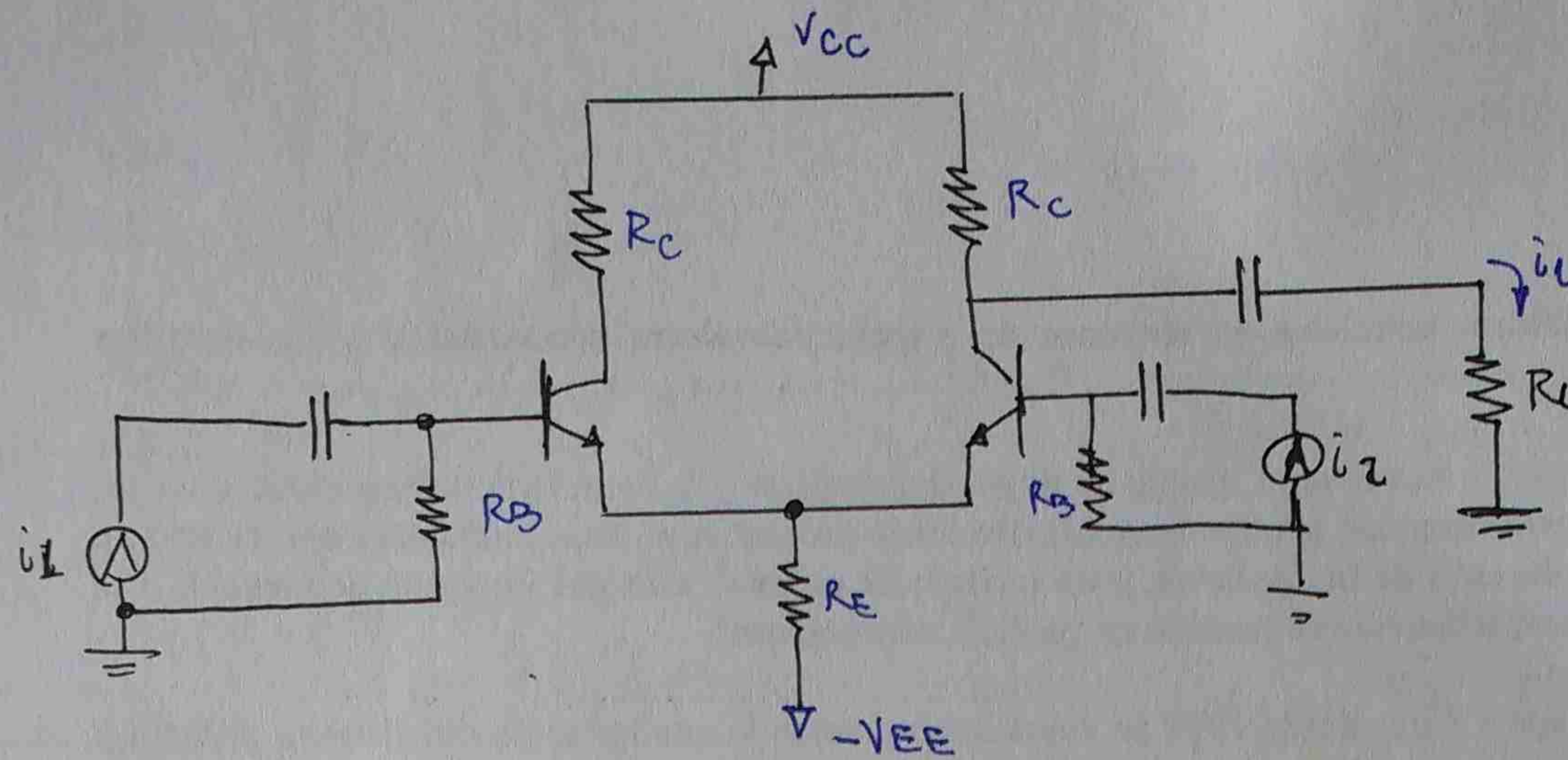
Con R_i hay que sumarle

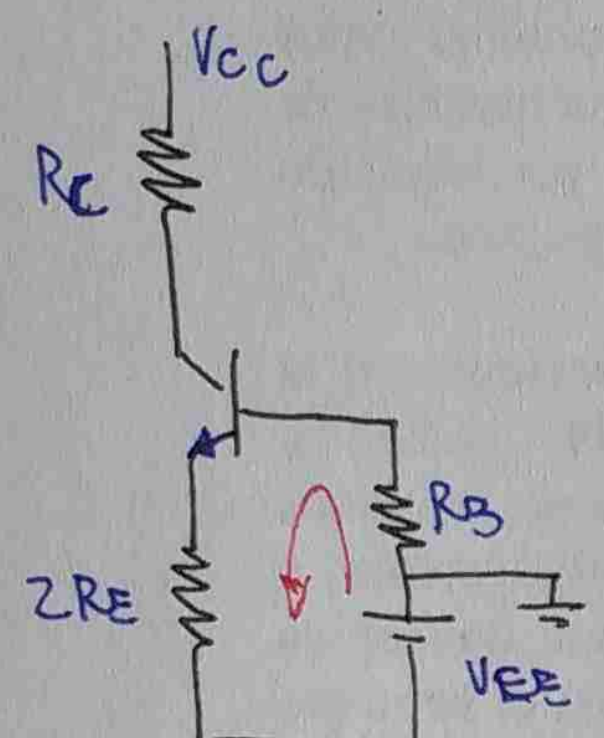
$$+\left(R_i // \frac{R_b}{h_{fe}^2}\right)$$

$$A_v = \frac{v_L}{v_i} = \frac{v_L}{i_{e2}} \cdot \frac{i_{e2}}{v_i} = R_E//R_L \frac{1}{2h_{ib2} + R_E//R_L}$$

$$A_i = A_v \frac{Z_i}{R_L}$$

Amplificador Diferencial





$$I_{RE} = I_{CQ1} + I_{CQ2} = 2I_{CQ1} = 2I_{CQ2}$$

$$V_{RE} = 2I_{CQ2}R_E = I_{CQ2}(2R_E)$$

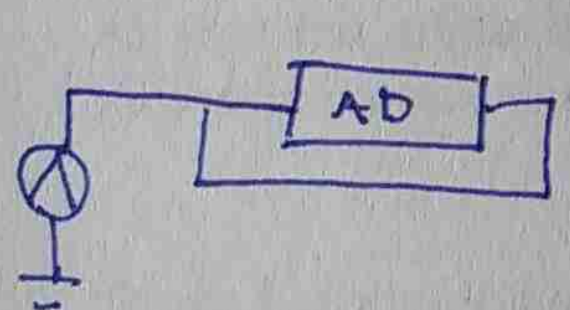
LKT

$$V_{EE} = \frac{I_{CQ2}}{\beta}R_B + V_{BE} + I_{CQ2}2R_E$$

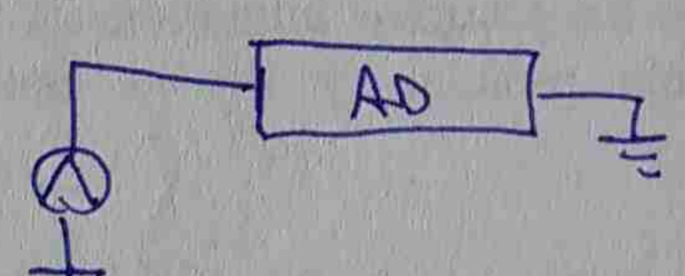
$$\boxed{I_{CQ} = \frac{V_{EE} - V_{BE}}{\frac{R_B}{\beta} + 2R_E}}$$

Modos conección

Común



Asimétrico



Diferencial

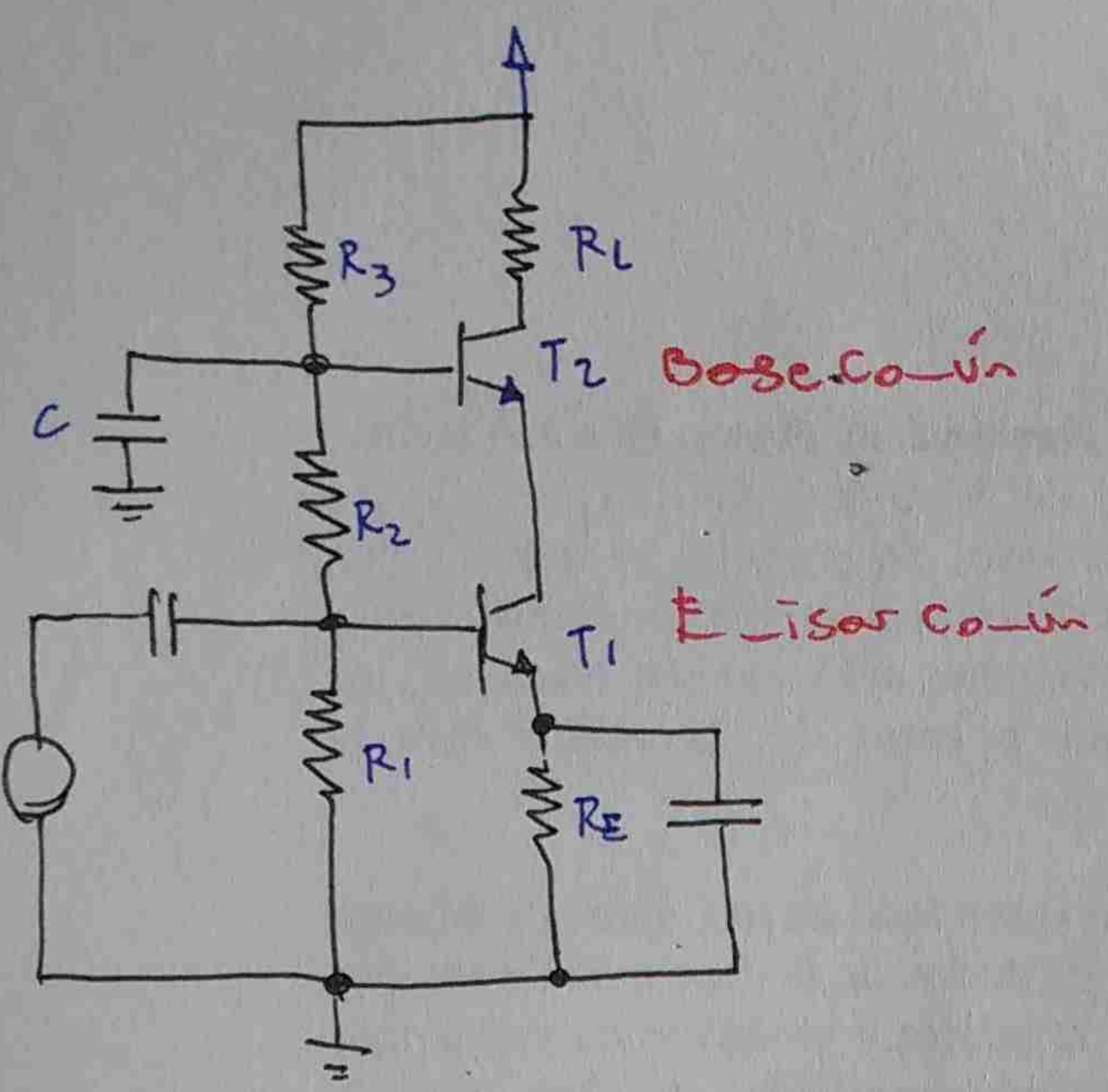
Relación de Rechazo en modo común

$$RRMC = \frac{A_d}{A_c}$$

A_d = ganancia en modo diferencial

A_c = ganancia en modo común

Amplificador cascode



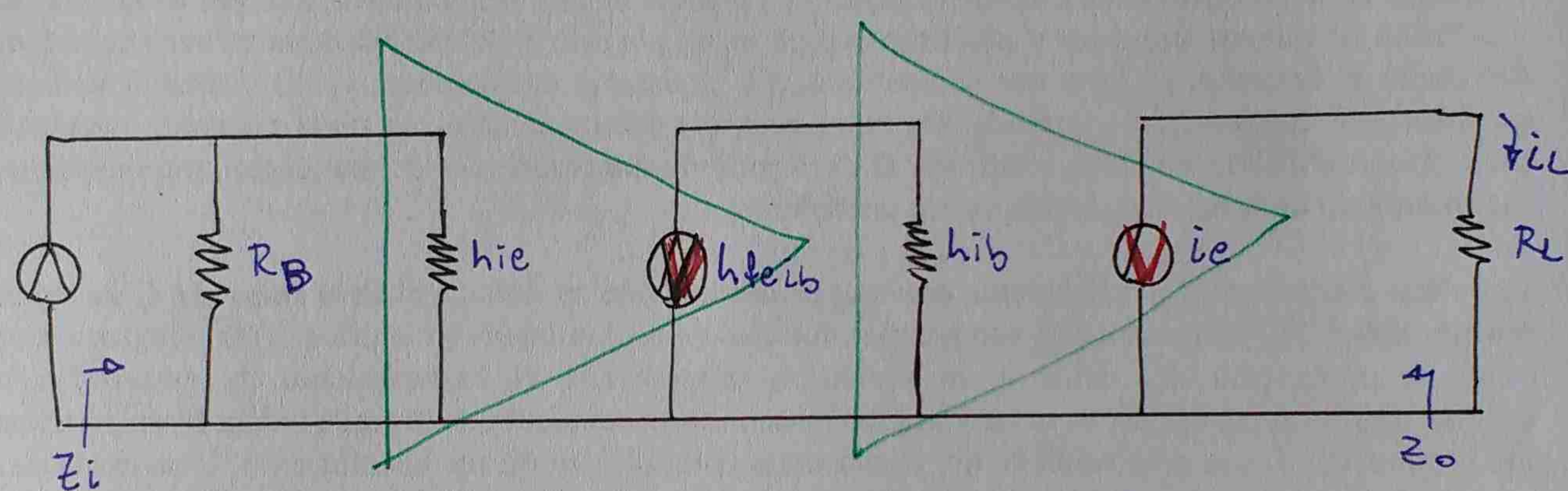
$$V_{B2} = \frac{V_{CC}}{R_1+R_2+R_3}(R_1+R_2)$$

$$V_{B1} = \frac{V_{B2}}{R_1+R_2} R_1$$

$$I_{CQ2} = \frac{V_{B1}-V_{BE}}{R_E}$$

$$V_{CEQ1} = V_{B2} - V_{BE} - I_{CQ1}R_E$$

$$V_{CEQ2} = V_{CC} - V_{CEQ1} - I_{CQ2}(R_L+R_E)$$



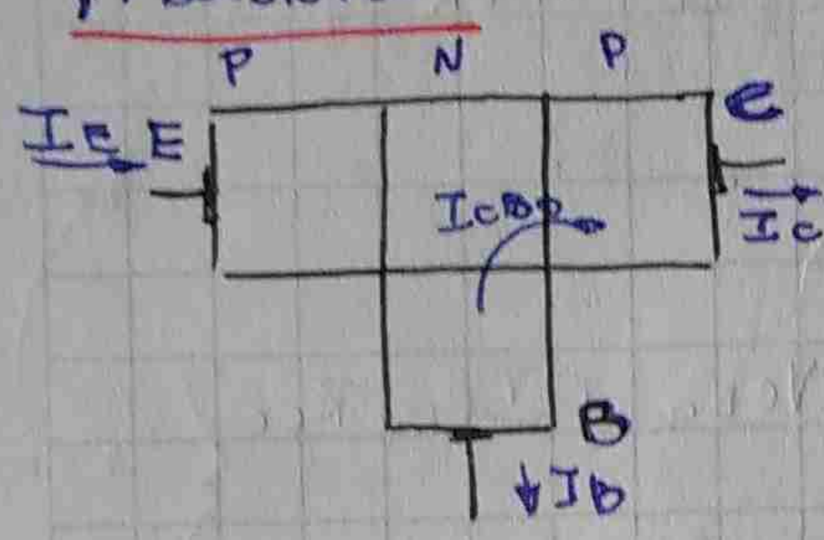
$$Z_o = \frac{1}{h_{ob}}$$

$$Z_i = R_B // h_{ie}$$

$$A_i = \frac{i_L}{i_i} = \frac{i_L}{i_e}\,\frac{i_e}{i_b}\,\frac{i_b}{i_i} = (-1)\,h_{fe}\,\frac{R_B}{R_B+h_{ie}}$$

El cascode preserva una impedancia de salida (entrada) al emisor común muy baja

Transistor



I_{CBO} = Corriente inversa con el ~~colector~~ emisor abierto

$I_E = I_C + I_B$

$\beta = \frac{I_C}{I_B}$ (Ganancia EC)

$\alpha = \frac{I_C}{I_E}$ (Ganancia BC)

$$\alpha = \frac{I_C}{I_E} = \frac{I_C}{I_C + I_B} = \frac{\frac{I_C}{I_B}}{\frac{I_C}{I_B} + 1} = \boxed{\frac{\beta}{\beta + 1}}$$

$$\beta = \frac{I_C}{I_B} = \frac{I_C}{I_E - I_C} = \frac{\frac{I_C}{I_E}}{1 - \frac{I_C}{I_E}} = \boxed{\frac{\alpha}{1 - \alpha}}$$

$I_C = \alpha I_E + I_{CBO}$ } Igualo I_E

$I_E = I_C + I_B$

$$I_B = I_C \underbrace{\left(\frac{1-\alpha}{\alpha}\right)}_{\beta} - \underbrace{\frac{I_{CBO}}{\alpha}}_{\text{Despreciable}}$$

$\beta = \frac{I_C}{I_B}$

$$h_{fe} = \frac{i_c}{i_b} = \frac{\Delta i_c}{\Delta i_B} = \beta \frac{\cancel{\Delta i_B}}{\cancel{\Delta i_B}} + \overbrace{i_B \frac{\Delta \beta}{\Delta i_B}}^{<<\beta} = \beta \Rightarrow \boxed{h_{fe} = \beta} \quad \boxed{h_{fb} = \alpha}$$

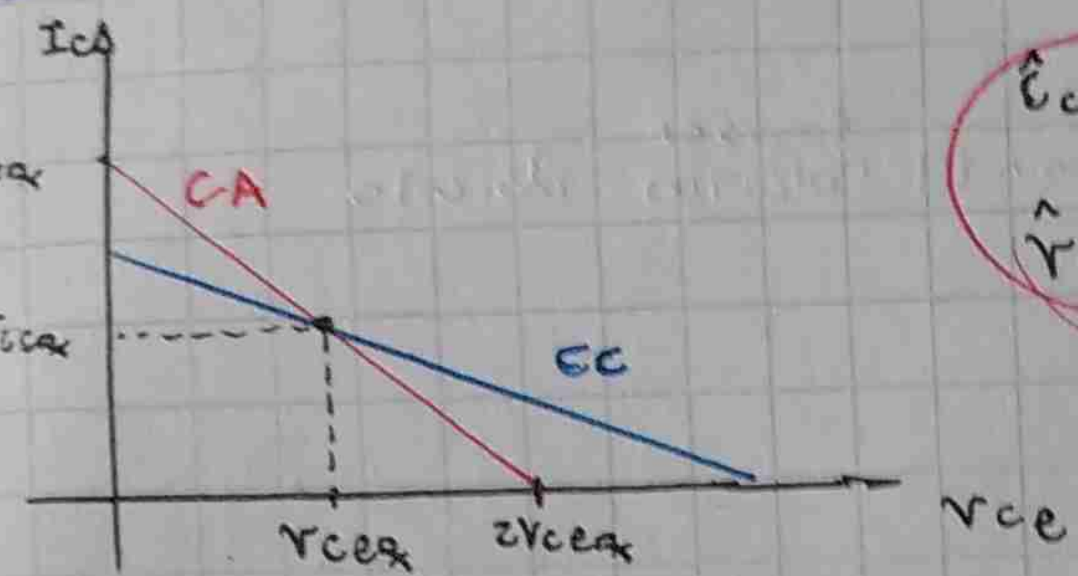
Ec. Diseño

1. $V_{CC} < \beta V_{CEO}$
2. R_e.
3. $R_C = \frac{V_{CC} - V_{CEQ}}{I_{CQ}} - R_e$
4. $R_B = \frac{\beta R_e}{10}$
5. $V_{BB} = \frac{I_{CQ}}{\beta} R_b + V_{be} + I_{CQ} R_e$
6. $R_1 = \frac{R_B}{1 - \frac{V_{BB}}{V_{CC}}}$ $\quad R_2 = \frac{R_B}{\frac{V_{BB}}{V_{CC}}}$

Entrada Directamente

Salida Inversamente

Máxima excursión simétrica



$\hat{i}_{c\,max} = I_{CQ}$

$\hat{v}_{CE\,max} = V_{CEQ}$

$$\boxed{I_{CQ\,MES} = \frac{V_{CC}}{R_{CC} + R_{CA}}}$$

Fórmula General

Demostración

CC → $V_{CC} = V_{CEQ} + I_{CQ} R_{CC}$ } igualo V_{CEQ}

CA → $(\hat{v}_{CE})_{max} = \hat{i}_{c\,max} R_{CA}$

Puntos extremos

$\hat{i}_c = I_{CQ} + \frac{V_{CEQ}}{R_{CA}}$

$v'_{ce} = V_{CEQ} + I_{CQ} R_{CA}$

Si $\boxed{I_{CQ} = \frac{V_{CEQ}}{R_{CA}}}$ MES (esta para)

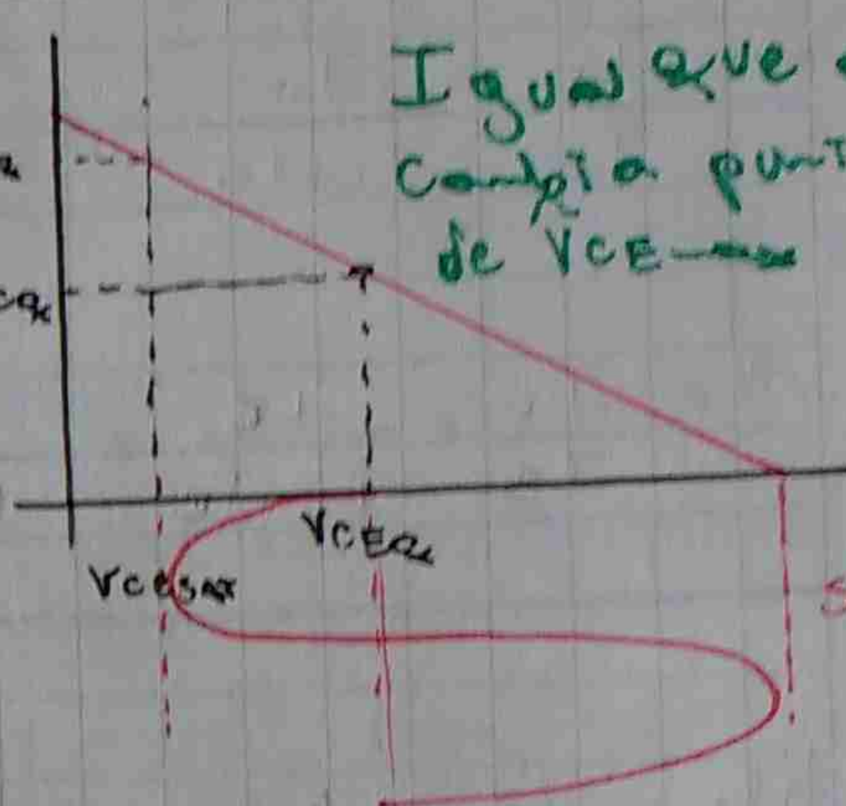
Puntos extremos
que paso en CC y en CA
Reemplazo puntos extremos
Igualo V_{CEQ}
Despejo I_{CQ}.

$V_{CEsat} \neq 0$

$\hat{i}_{c\,max} = I_{CQ}$

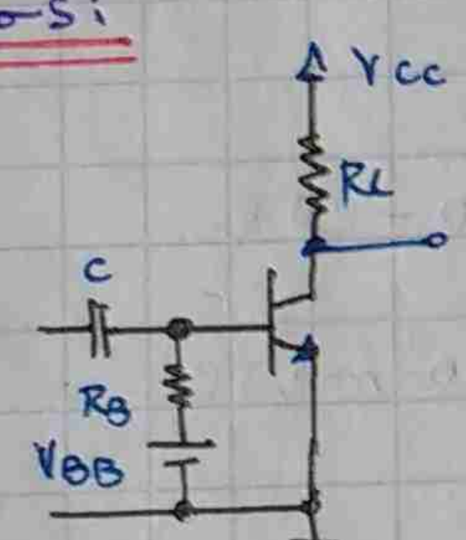
$\hat{v}_{ce\,max} = V_{CEQ} - V_{CEsat}$

$I_{CQ} = \frac{V_{CC} - V_{CEsat}}{R_{CC} + R_{CA}}$



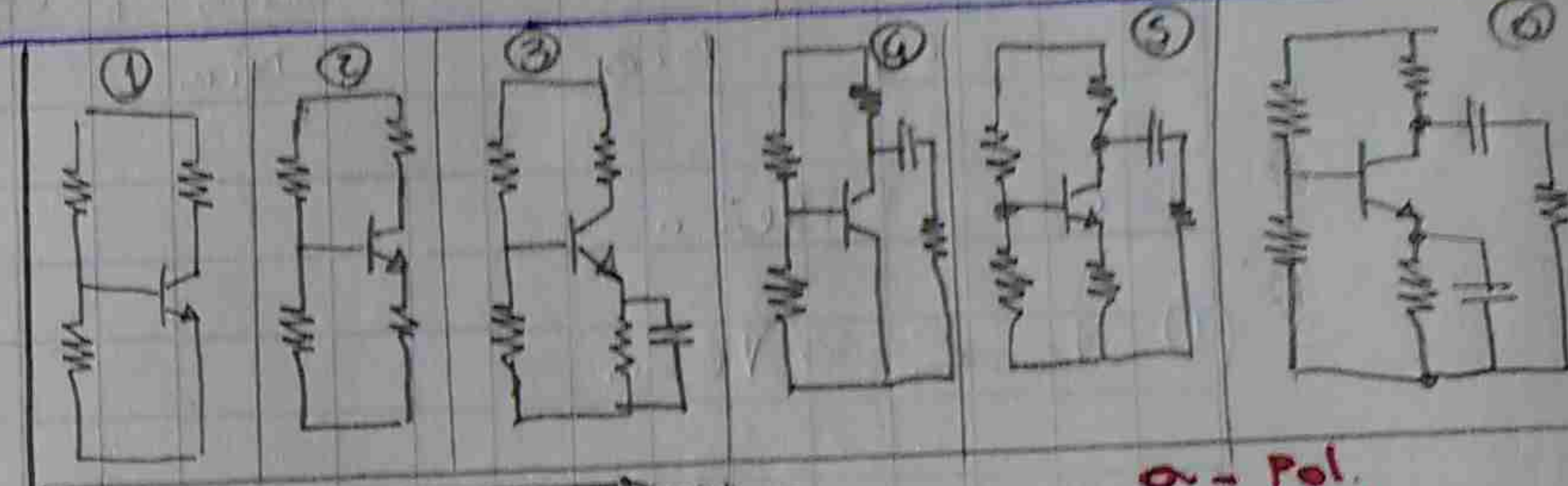
Igual que antes
Cambia punto extremo de $V_{CE\,min}$

Potencias



$R_C << R_L$ ($R_E = 0$)

$i_C(t) = \underbrace{I_{CQ}}_{CC} + \underbrace{\hat{i}_c \cos(\omega t)}_{CA}$



1 - 4 - 2 - 5 - 3 - 6 → Mejor
a a b b c NADA
c c

a – Pol.
b – pérdida por
c – R = f(RL)

En general

$P = \frac{1}{T}\int_0^T V_{CC}\, i_C(t)\, dt = \frac{1}{T}\int_0^T V_{CC}\,(I_{CQ} + \hat{i}_c \cos \omega t)\, dt = \frac{1}{\cancel{T}} V_{CC} I_{CQ} \cancel{T}$

Potencia por la fuente entrega

$\boxed{P_{CC} = V_{CC} I_{CQ}}$

Para MES.

$I_{CQ\,MES} = \frac{V_{CC}}{2R_L}$ $\quad \boxed{P_{CC\,max} = \frac{V_{CC}^2}{2R_L}}$ $\quad \boxed{P_{L\,max} = \frac{V_{CC}^2}{8R_L}}$ $\quad P_{L\,max} = \frac{1}{2} I_{CQ}^2 R_L$ ← MES

Pot prom disipada en la carga (CA)

$P_{L(CA)} = \frac{1}{T}\int_0^T \hat{i}_c^2 R_L\, dt = \frac{1}{T} \hat{i}_c^2 R_L \int_0^T \cos^2(\omega t)\, dt = \ldots = \frac{1}{\cancel{T}} \frac{\hat{i}_c R_L}{2} \cancel{T}$ $\quad \boxed{P_{L(CA)} = \frac{1}{2} \hat{i}_c^2 R_L}$

Solo la parte de Alterna

Potencia promedio disipada en el colector del transistor

$v_{ce} = V_{CC} - i_C R_L$

$i_C = I_{CQ} + i_c$

$i_c = \hat{i}_c \cos(\omega t)$

$P_C = \frac{1}{T}\int_0^T v_{ce}\, i_C\, dt = \left|\begin{matrix}\text{distribuis} \\ \text{simplif.}\end{matrix}\right| = V_{CC} I_{CQ} + 0 - \frac{\hat{i}_c^2 R_L}{2T}\left[\int_0^T dt + \int_0^T \cos 2\omega t\, dt\right]$

$$\boxed{P_C = V_{CC} I_{CQ} - I_{CQ}^2 R_L - \frac{1}{2} \hat{i}_c^2 R_L}$$

Deducir desde la máxima menos las pérdidas (colector, carga (CC) (CA))

PARA MES

$$\boxed{P_C = \frac{V_{CC}^2}{2R_L} - \frac{V_{CC}^2}{4R_L} - \frac{V_{CC}^2}{8R_L}}$$

$\hat{i}_{c\,max} = I_{CQ}$

$I_{CQ} = \frac{V_{CC}}{2R_L}$

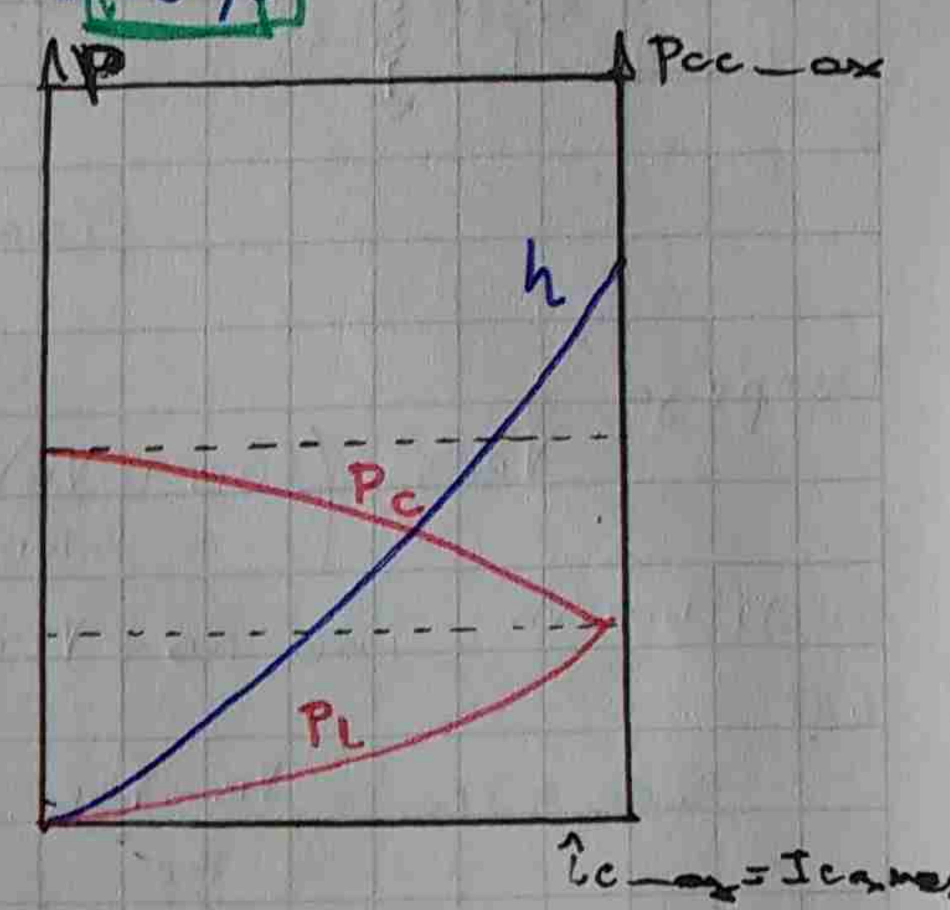
$P_{C\,max} = P_C\Big|_{s/señal} = \frac{V_{CC}^2}{4R_L}$

$P_{C\,min} = P_C\Big|_{c/señal_{max}} = \frac{V_{CC}^2}{8R_L}$

Rendimiento

Mayor valor posible → $\boxed{\eta = \frac{P_L}{P_{cc}}}$
Pot útil en la carga / Pot suministrada por fuente de salida

$\eta_{max} = \frac{P_{L\_max}}{P_{cc\_max}} = \boxed{25\%}$



Factor de Mérito

ocurren en dist. momentos

Menor valor posible → $\boxed{F_M = \frac{P_{c\_max}}{P_{L\_max}}}$ ← max pot disip. colector / ← " " " carga

Si no estuviera para MES $F_M > 2$ trans es mas grande

P/MES $\boxed{F_M = 2}$

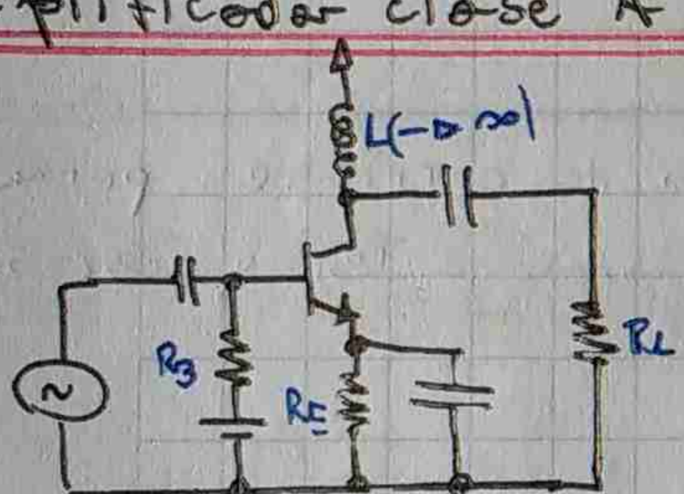
Con $\eta = 25\%$

$P_{cc\_max} = \frac{P_{L\_max}}{0.25} = V_{cc}\boxed{I_{cq\,mes}}$

Con $F_M = 2$

$\boxed{P_{c\_max}} = 2P_{L\_max}$

Amplificador clase A con acoplamiento por inductor (EC)

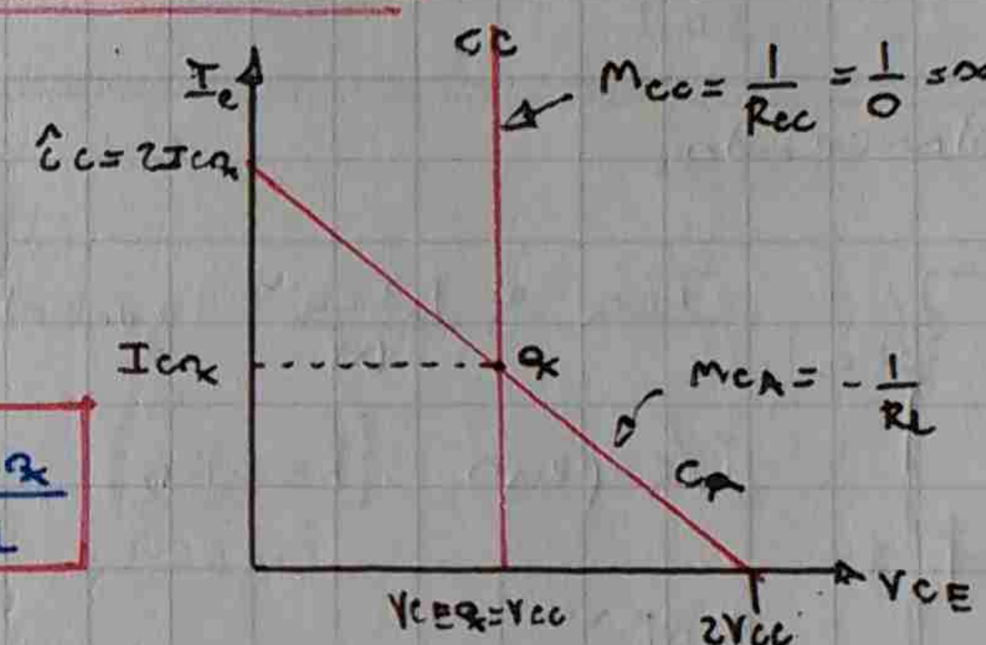


$R_E \to 0$

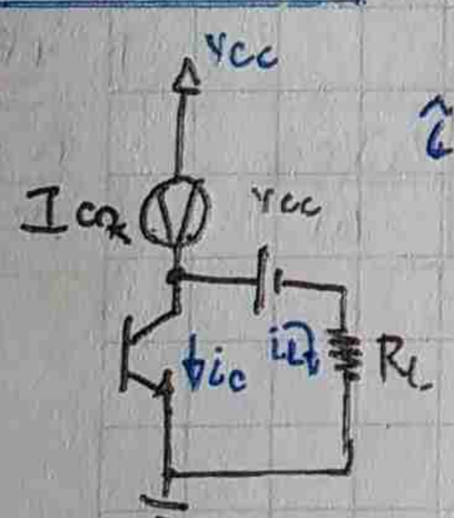
$R_{CC} \simeq 0$

$R_{CA} = R_L // X_L = R_L$

$\boxed{I_{cq\,mes} = \frac{V_{cc}}{R_L} = \frac{V_{CEq}}{R_L}}$



Funcionamiento



$\hat{i}_L = -\hat{i}_c$

- P/ $i_c = 0$
  $v_{ce} = V_{cc} + \hat{i}_L R_L$
  $V_{cc} + I_{cq} R_L$
  $\underline{v_{ce} = 2V_{cc}}$
- P/ $i_c = 2I_{cq}$
  $v_{ce} = V_{cc} - \hat{i}_c R_L$
  $v_{ce} = 0$

Analisis de Potencia

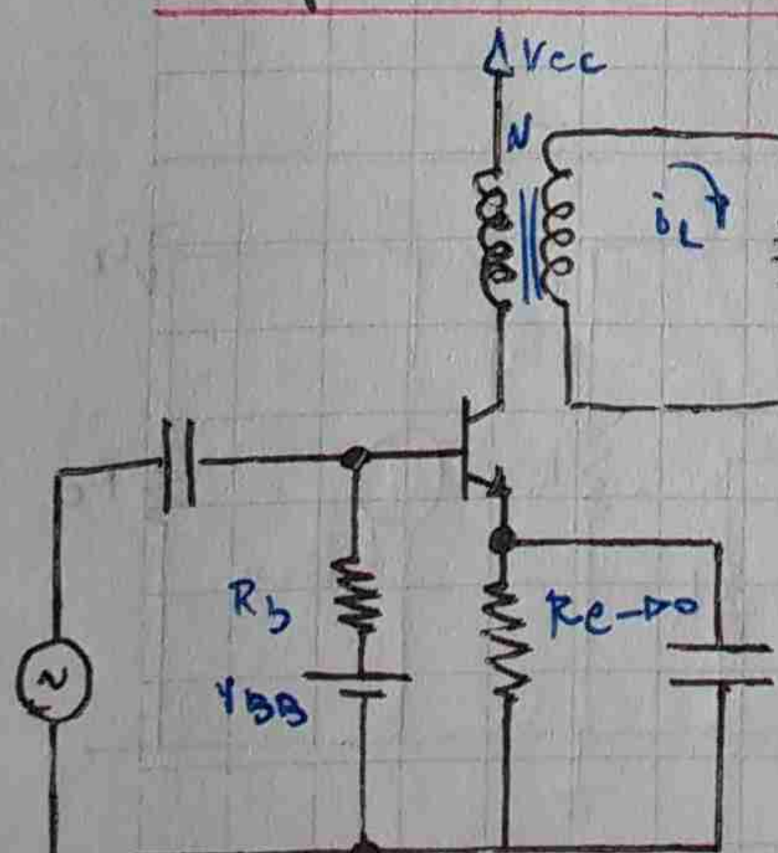
$P_{cc\_max} = \frac{V_{cc}^2}{R_L}$ $\quad P_{c\_max} = \frac{V_{cc}^2}{R_L}$

$P_{L(CA)\,max} = \frac{V_{cc}^2}{2R_L}$ $\quad P_{c\_min} = \frac{V_{cc}^2}{2R_L}$

$\eta_{max} = 50\%$

$F_M = 2$

Amplificador clase A (Acoplamiento por transformador)



$\boxed{i_c R'_L = i_L R_L}$ Se reemplaza R_L por R'_L

$N = \sqrt{\frac{Z_P}{Z_S}} = \sqrt{\frac{R'_L}{R_L}}$ $\quad \boxed{R'_L = N^2 R_L}$

$I_{cq1} = \frac{P_{L\_max}}{V_{CEq1}}$

$I_{cq2} = \frac{i_{c\_max}}{2}$

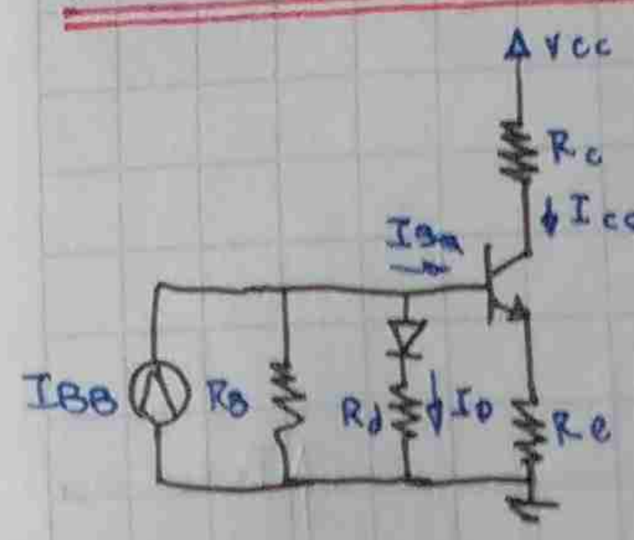
$N_{max} = \frac{1}{I_{cq1}}\sqrt{\frac{2P_{L\_max}}{R_L}}$

$N_{min} = \frac{1}{I_{cq2}}\sqrt{\frac{P_{L\_max}}{R_L}}$

$N = \frac{N_{max} - N_{min}}{2}$

$P_L = \frac{1}{2} i_c^2 R'_L$

Polarización por diodo o transistor



$$\boxed{\frac{\Delta V_D}{\Delta T} = \frac{\Delta V_{BE}}{\Delta T} = -K}$$

$$I_{BB} = \frac{V_B}{R_B} + \frac{V_B - V_D}{R_D} + I_{BQ}$$

$$I_{BQ} = V_B\left(\frac{R_B+R_D}{R_B \cdot R_D}\right) - \frac{V_D}{R_D}$$

Despejo $V_B = \left(I_{BB} + \frac{V_D}{R_D}\right) R_B /\!/ R_D$

Distributiva $I_{BB}\ R_B = V_{CC}$

LKT

$$I_{CQ} \simeq I_{EQ} = \frac{V_B - V_{BE}}{R_E}$$

ΔI_{CQ} con respecto a ΔT

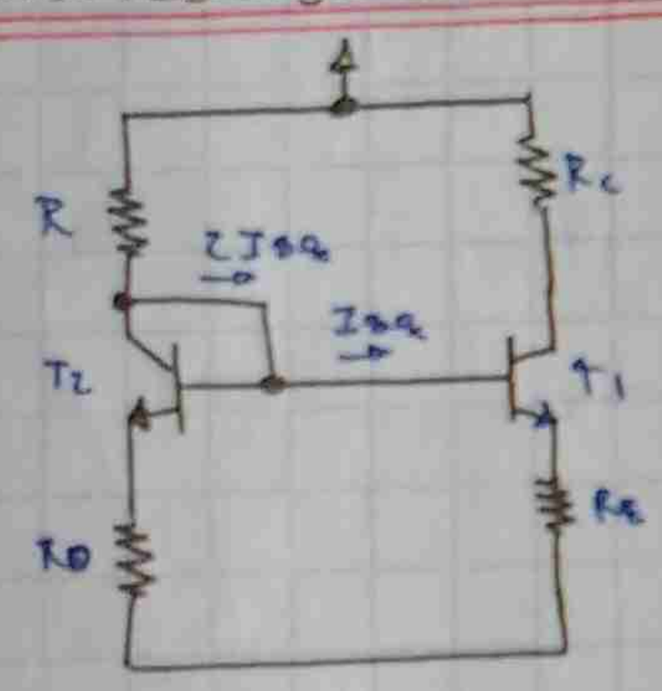
$$\boxed{\frac{\Delta I_{CQ}}{\Delta T} = \frac{K}{R_E} \cdot \frac{1}{1 + \frac{R_B}{R_D}}}$$

$$I_{CQ} = \frac{1}{R_E(R_B+R_D)}\left(V_{CC}R_D + V_D R_B - V_{BE} R_B - V_{BE} R_D\right)$$

$$I_{CQ} \simeq \frac{(V_{CC} - V_{BE}) R_d}{(R_B + R_D)\ R_E}$$

Polarización Balanceada

Espejo de corriente porque ya es el mismo o I_{B1} y I_{B2} son iguales



I_{CQ} y $\frac{\Delta I_{CQ}}{\Delta T}$ igual al diodo

P/espejo $\boxed{R_E = R_D}$

LKT

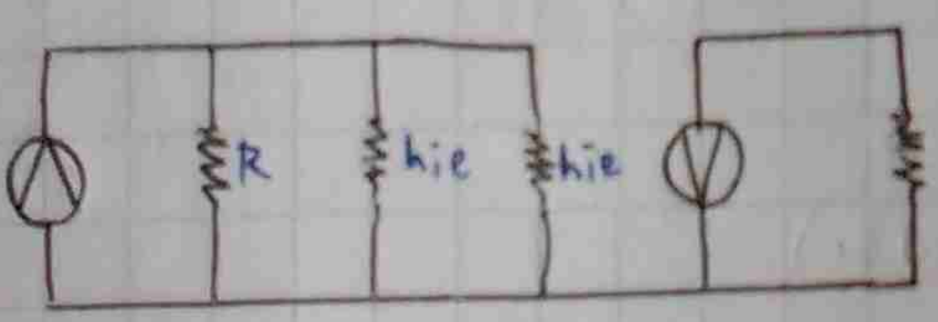
$$V_{CC} = \left(I_{CQ} + \frac{2 I_{CQ}}{\beta}\right) R + V_{BE} + I_{CQ} R_E = I_{CQ}\left[\frac{\beta+2}{\beta} R + R_E\right] + V_{BE}$$

Si $\beta >> 2$

$$\boxed{I_{CQ} = \frac{V_{CC} - V_{BE}}{R + R_E}}$$

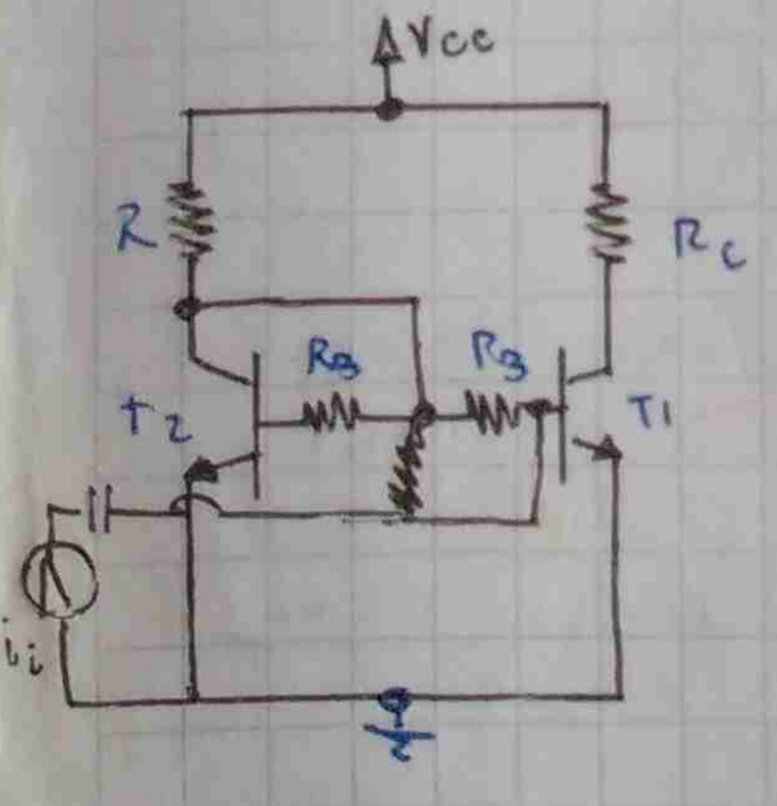
$$\boxed{\frac{\Delta I_{CQ}}{\Delta T} = \frac{K}{R + R_E}}$$

Haciendo $R_E = R_d = 0$ $\boxed{I_{CQ} = \frac{V_{CC} - V_{BE}}{R}}$ $\boxed{\frac{\Delta I_{CQ}}{\Delta T} = \frac{K}{R}}$ $\boxed{K = 2{,}5 \frac{mV}{°C}}$



$$\left.\begin{array}{l} R >> h_{ie} \\ i_i = 2 i_b \end{array}\right\} A_i = \frac{i_L}{i_b}\frac{i_b}{i_i} = \frac{h_{fe}}{2}$$

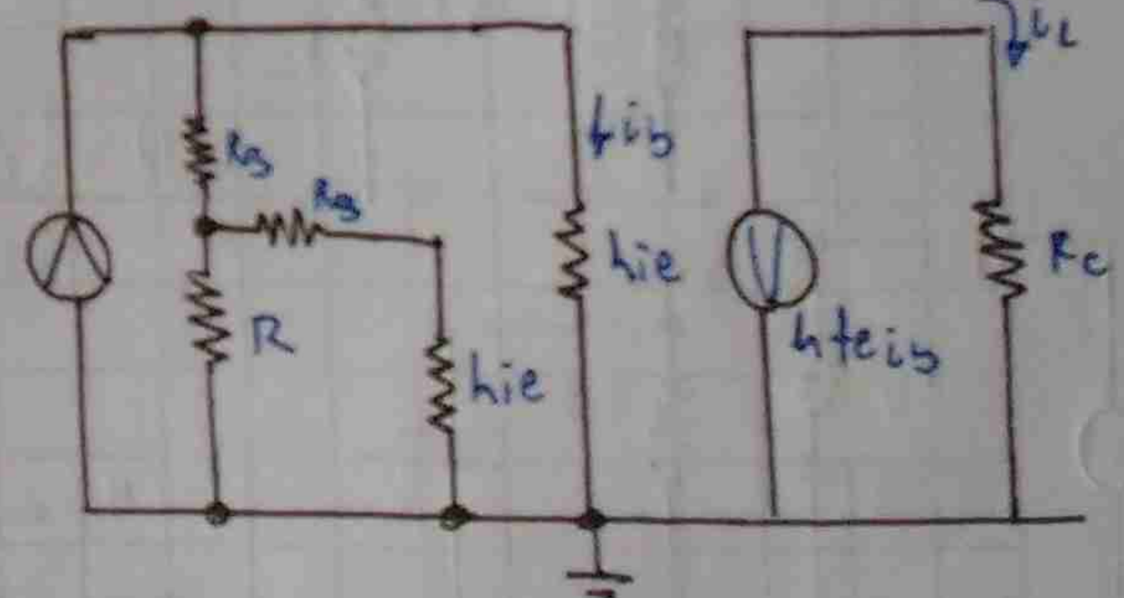
- Mejora



$$V_{CC} = \left(I_{CQ} + \frac{2 I_{CQ}}{\beta}\right) R + \frac{I_{CQ}}{\beta} R_B + V_{BE}$$

$$I_{CQ} = \frac{V_{CC} - V_{BE}}{\left(\frac{\beta+2}{\beta}\right) R + \frac{R_B}{\beta}}$$

si $\frac{R_B}{\beta} << R$ igual que antes.

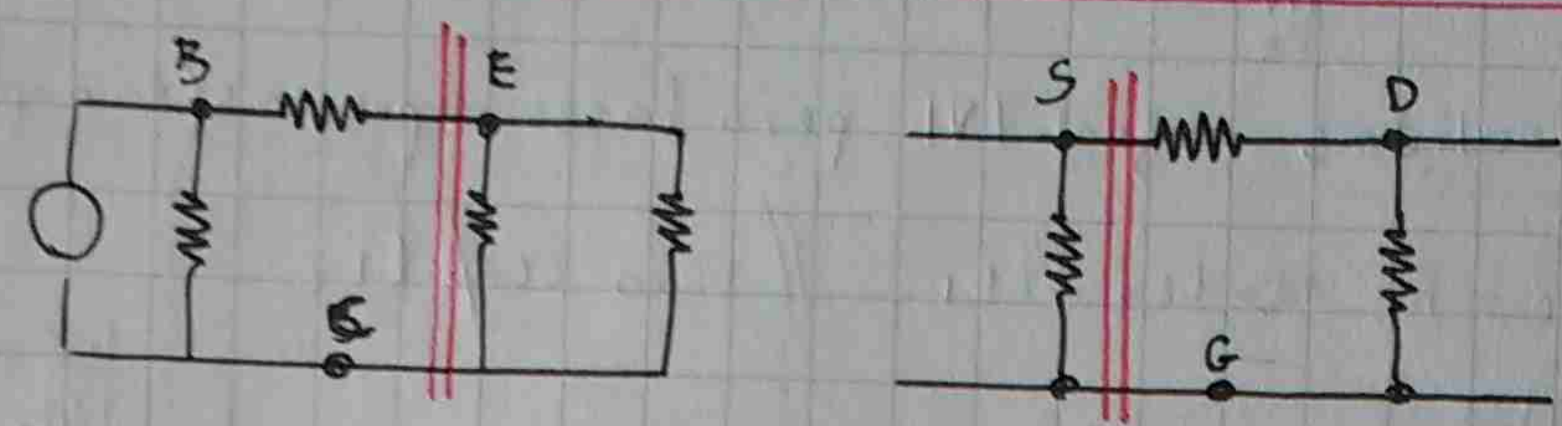


$\boxed{A_i = h_{fe}}$

$R_B >> h_{ie}$

3

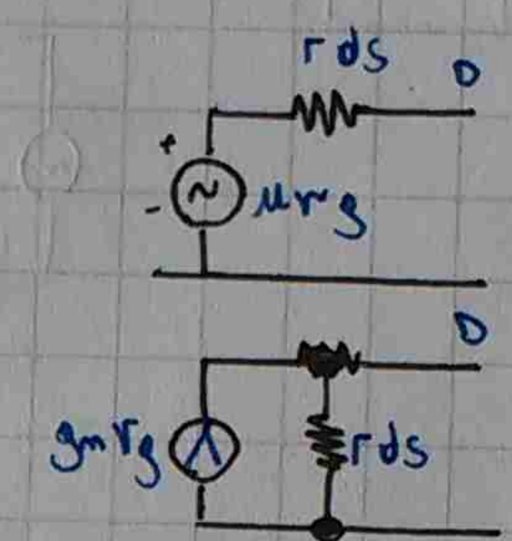
$$\boxed{\text{Transistores Bipolares} \to \text{refl imp} \to \overset{ie>>ib}{\underset{hfe}{E-B}} \qquad r = cte = \overset{\uparrow\downarrow}{\underset{\downarrow\uparrow}{i\,R}}}$$



Transistor efecto campo

MOSFET $\quad i_D = I_{DSS}\left(1+\frac{V_{GS}}{V_{PO}}\right)^2$

JFET $\quad i_D = I_{DSS}\left[1+\frac{3V_{GS}}{V_{PO}} + 2\left(-\frac{V_{GS}}{V_{PO}}\right)^{3/2}\right]$



$\mu r g$

$g_m r g$

$$\boxed{\mu = r_{ds}\, g_m}$$

Parámetros

$r_{gs} = \frac{v_{gs}}{i_g} \to \infty$

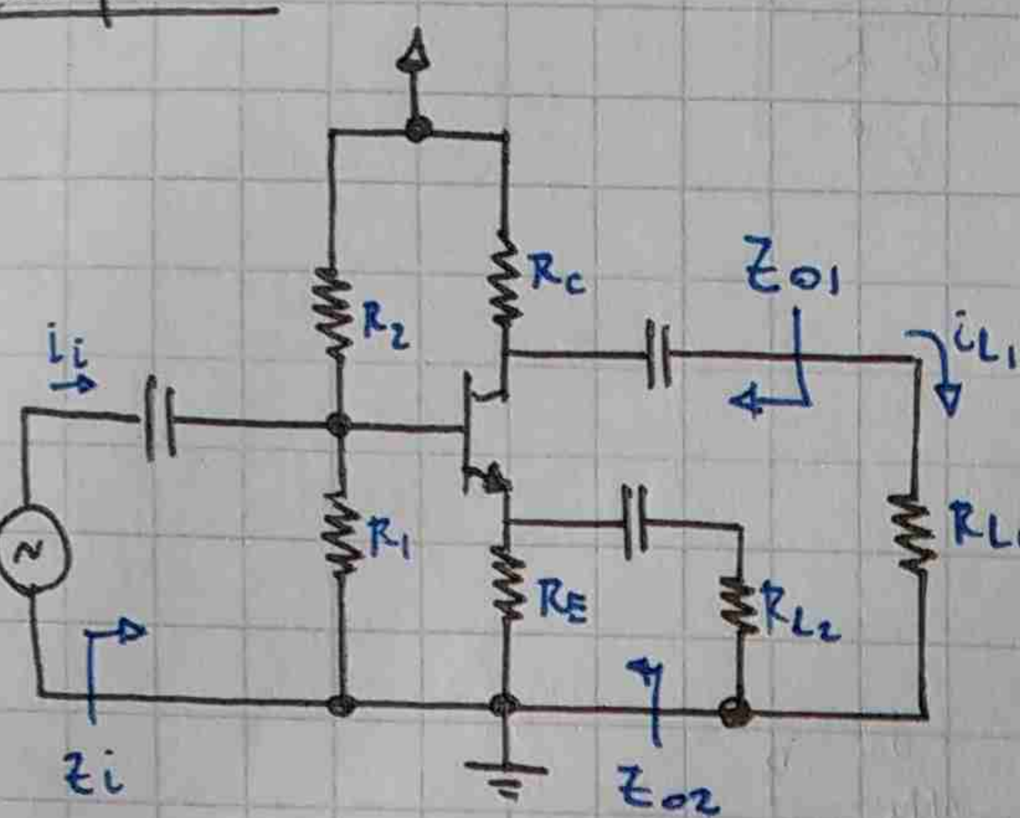
$\mu = \frac{v_{ds}}{v_{GS}}\Big|_{I_{DQ}}$

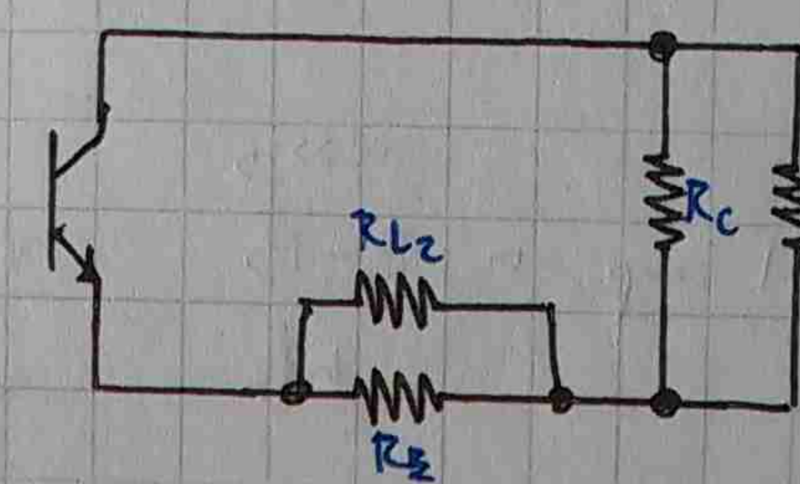
$r_{ds} = \frac{v_{DS}}{i_D}\Big|_{V_{GSQ}}$

$g_m = \frac{i_D}{v_{GS}}\Big|_Q$

Inversor de fase.

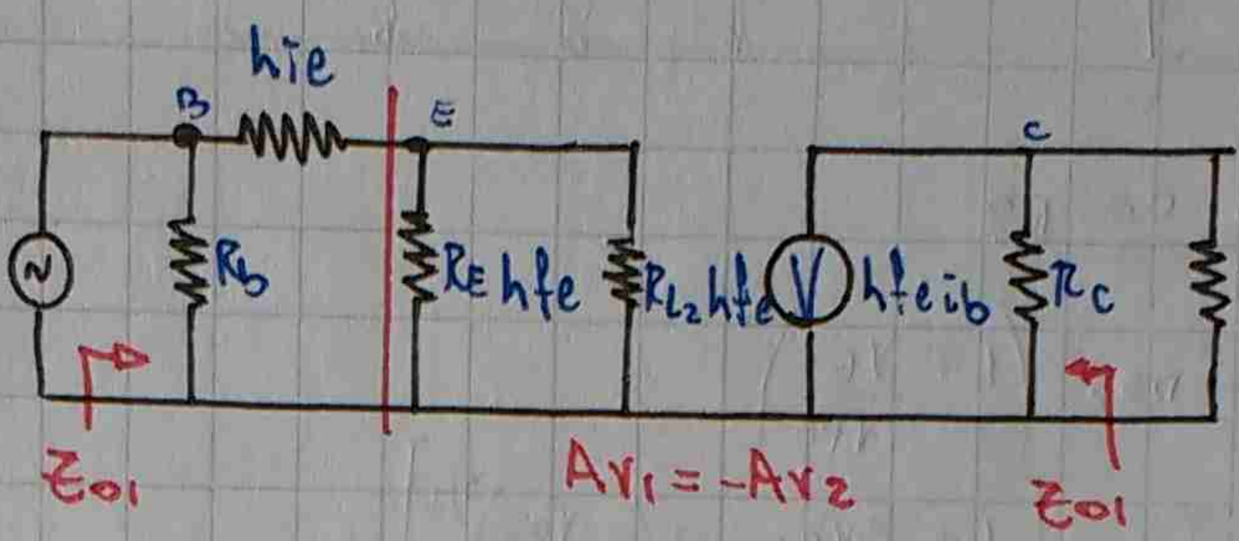
Bipolar

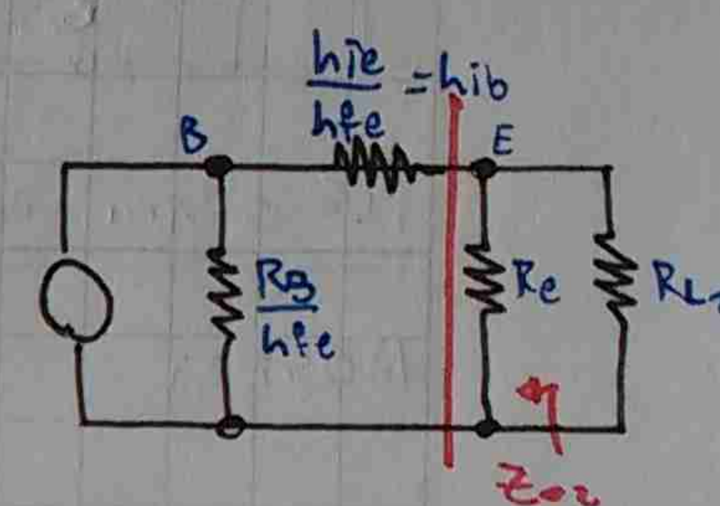




$\boxed{R_C \| R_{L1} = R_{L2} \| R_E}$

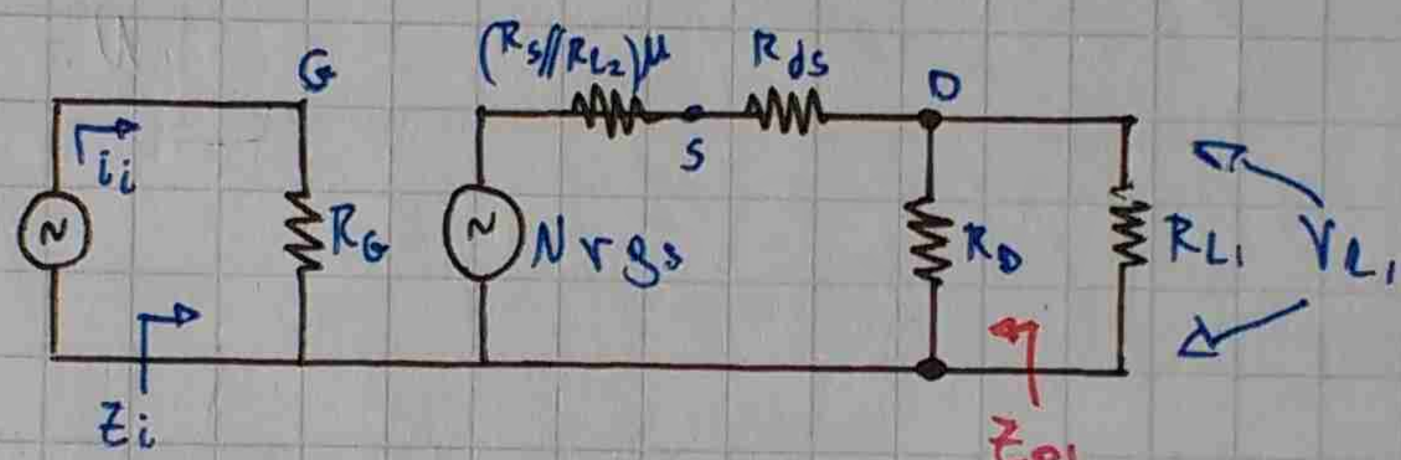
- Dos salidas, igual $|V|$ pero fases opuestas (No amplifica tensión)
- Si $R_C = R_e \Rightarrow i_{L2} = i_{L1}$ // sino $i_{L1} \neq i_{L2}$

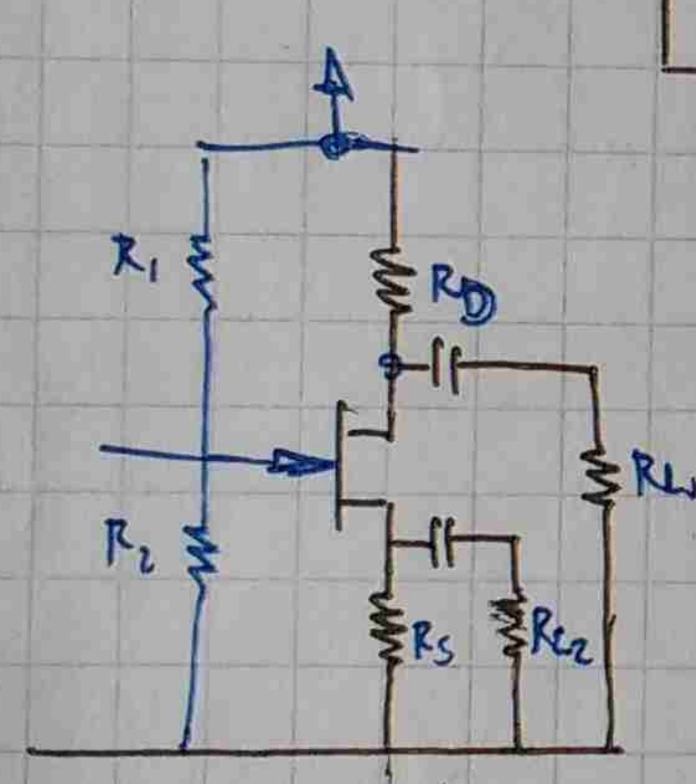


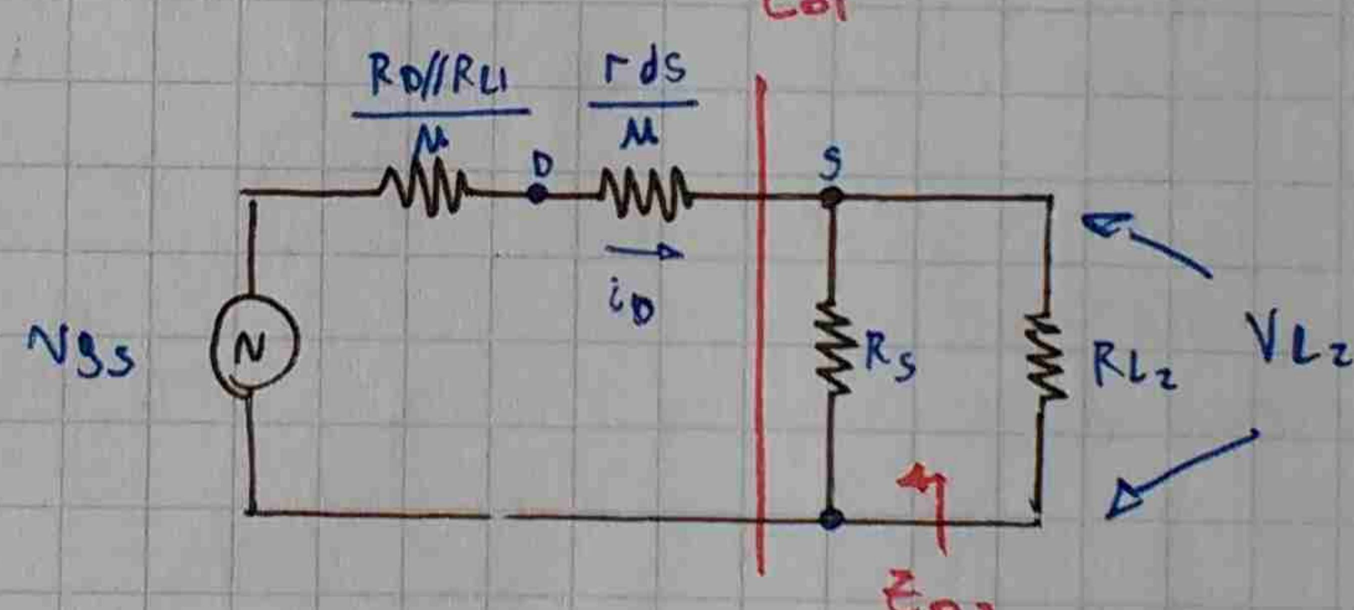


FET

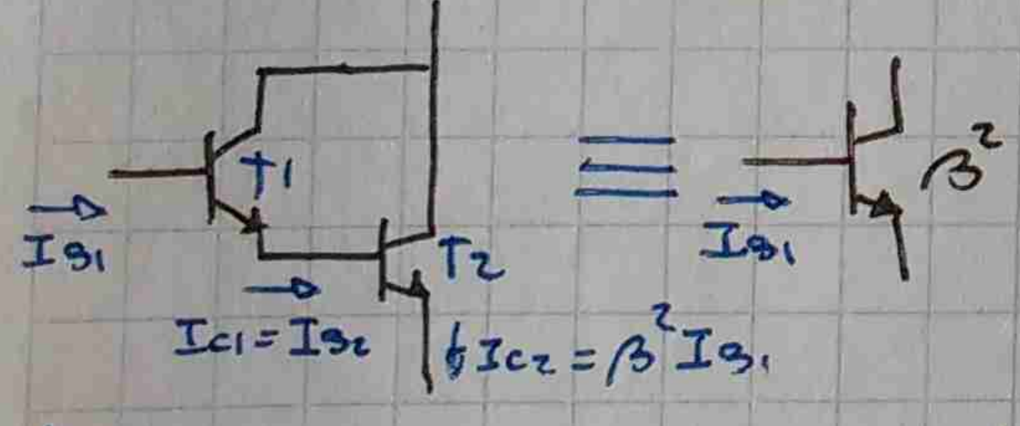
Mismo circuito.



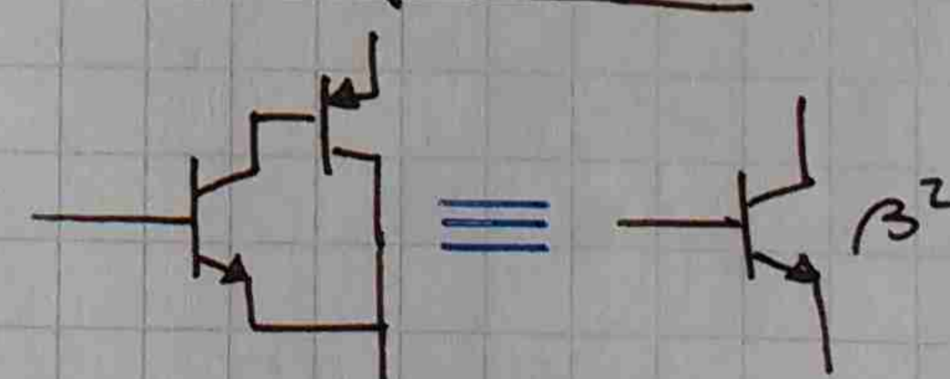




Par darlington



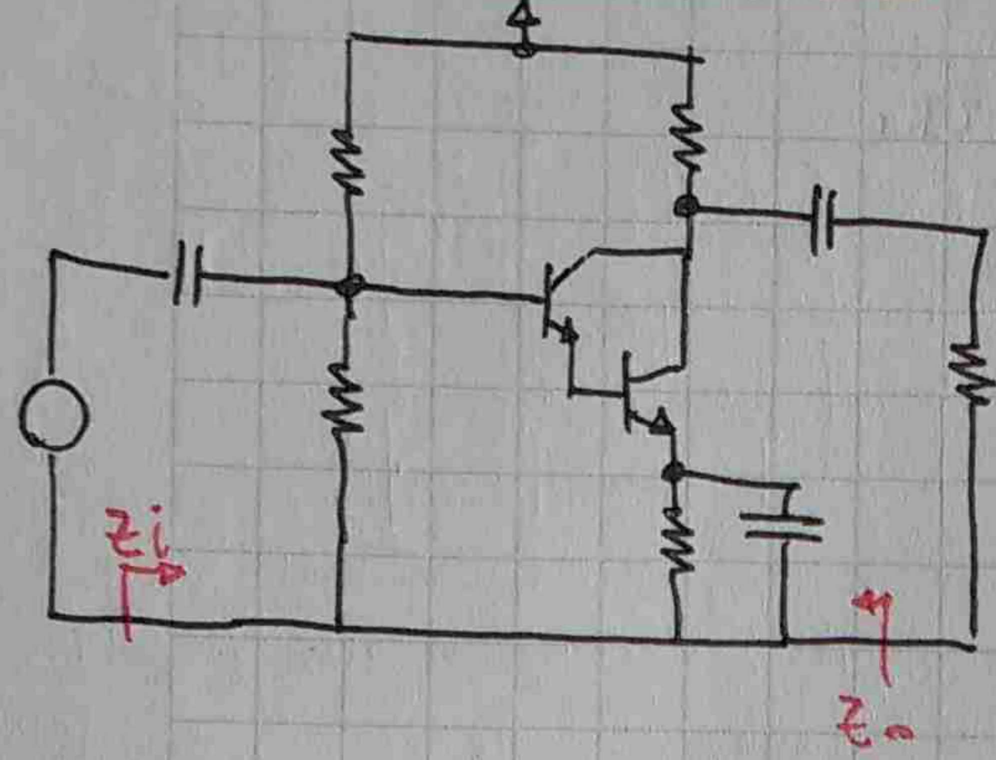
Par Complementario



Los dos transistores pueden ser iguales. Siempre que T1 sea igual a T2

Si son iguales T1 trabaja algo...

Salida por Colector



$\beta_1 = \beta_2$
$h_{fe1} = h_{fe2}$

$\Rightarrow \boxed{CC} = \boxed{EC} \Rightarrow$

$$I_{CQ2} = \frac{V_{BB} - 2V_{BE}}{R_e + \frac{R_B}{\beta^2}}$$

$$I_{BQ2} = \frac{I_{CQ2}}{\beta} \simeq I_{CQ1}$$

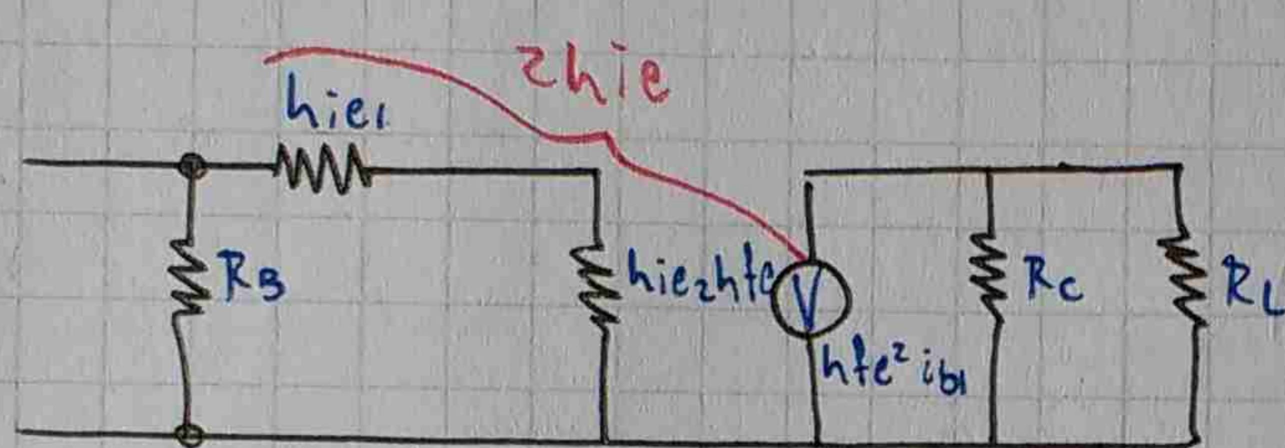
$$V_{CEQ2} = V_{CC} - I_{CQ2}(R_C + R_E)$$

$$V_{CEQ1} = V_{CEQ2} - V_{BE}$$

Diseño

$$R_B = \frac{\beta^2 R_e}{10}$$

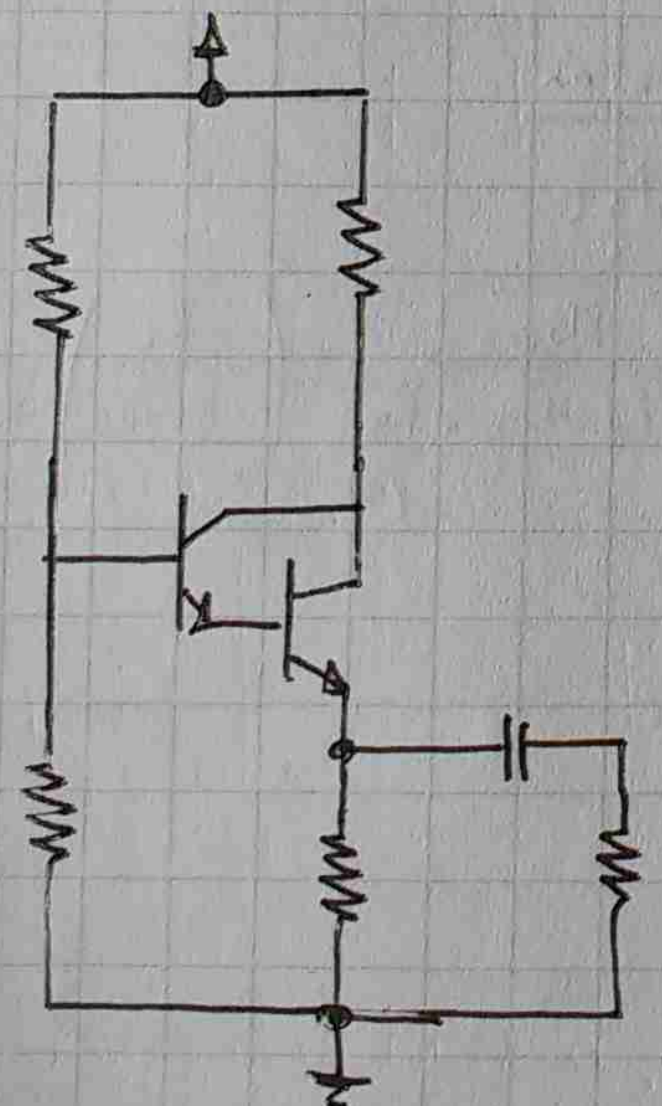
$$V_{BB} = I_{CQ2}\left(\frac{R_B}{\beta^2} + R_E\right) + 2V_{BE}$$



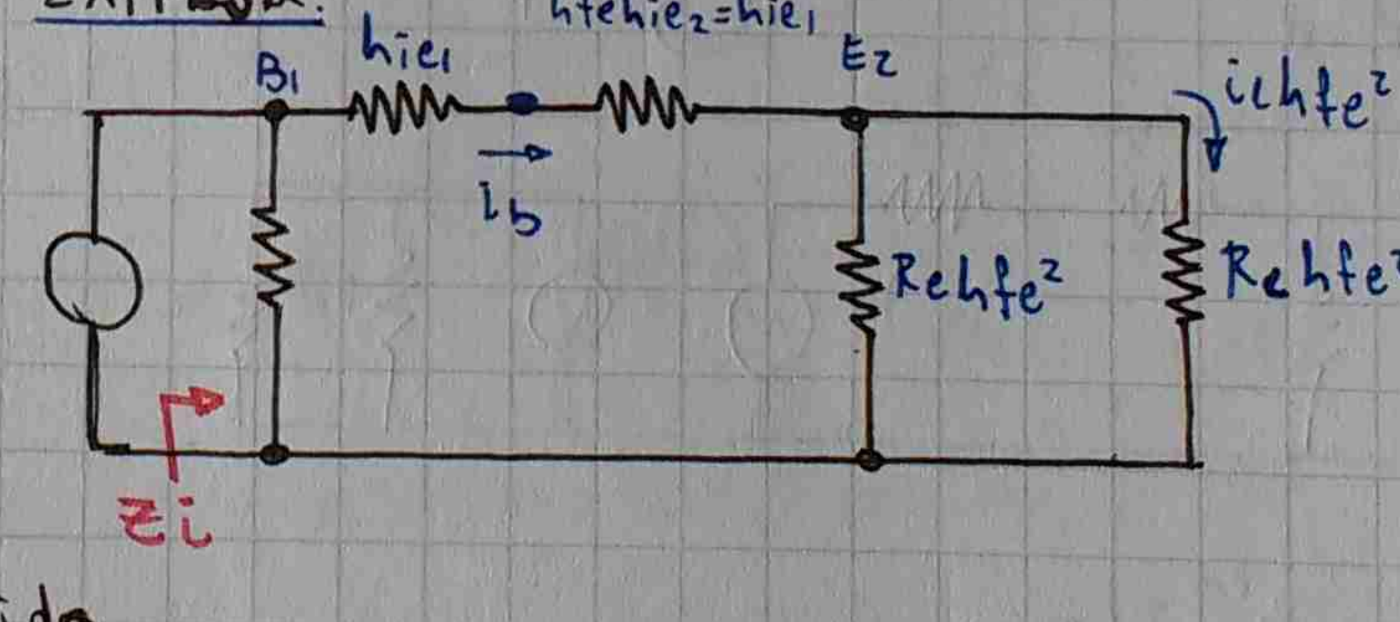
$$\boxed{h_{ie2} = \frac{h_{ie1}}{h_{fe}} = h_{ib1}}$$

Al Agregar un Transistor (PD) ahora desde la B1 la impedancia aumenta en un factor de 2hfe

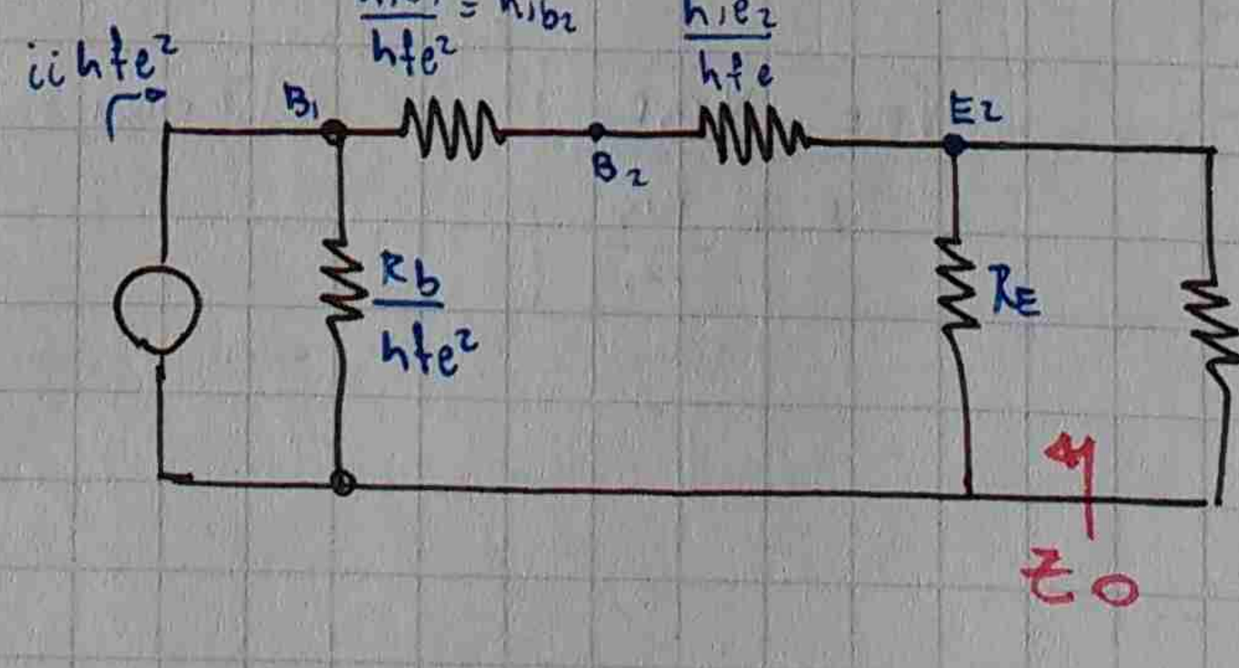
Salida Por emisor



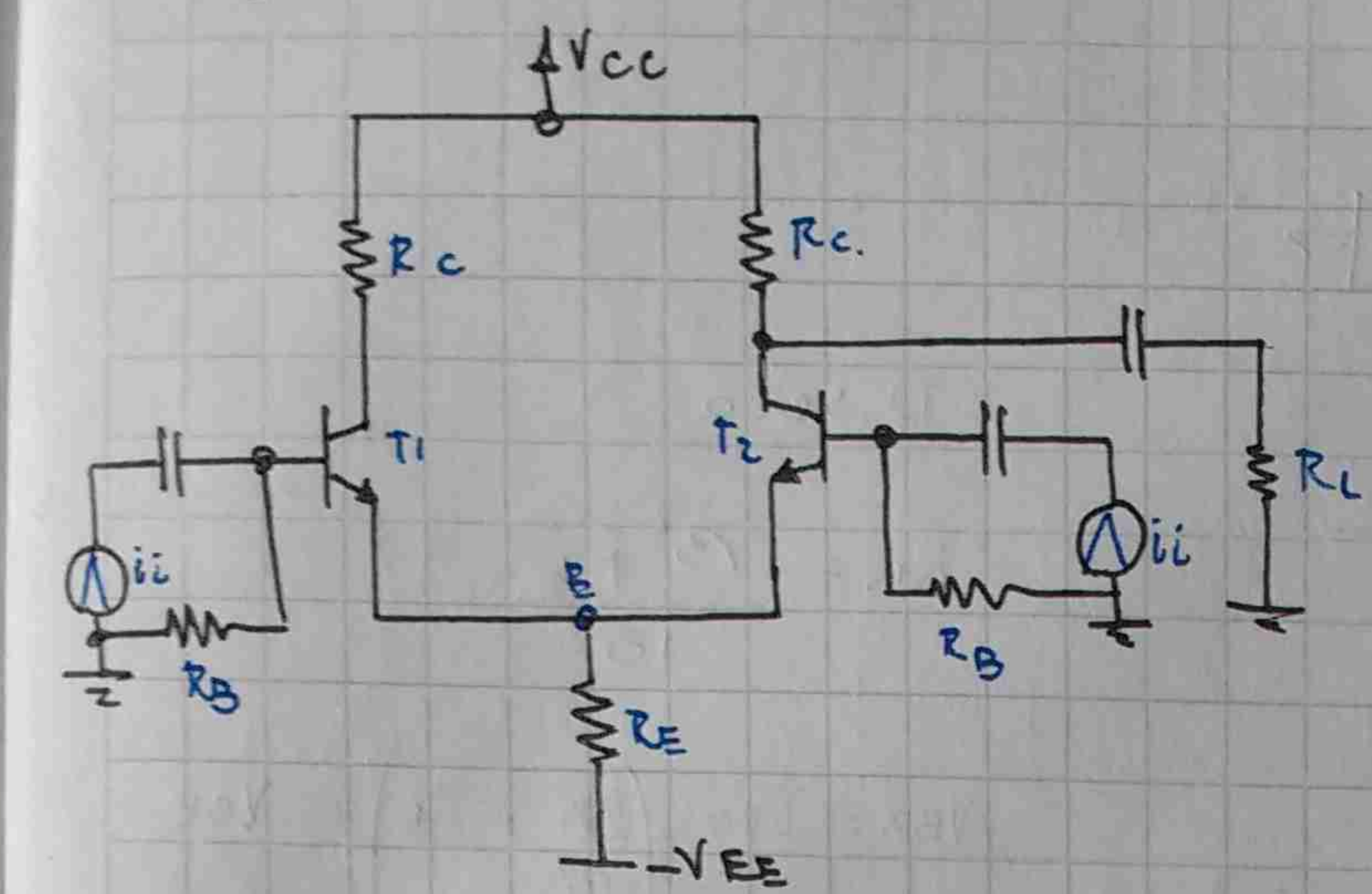
Entrada.



Salida



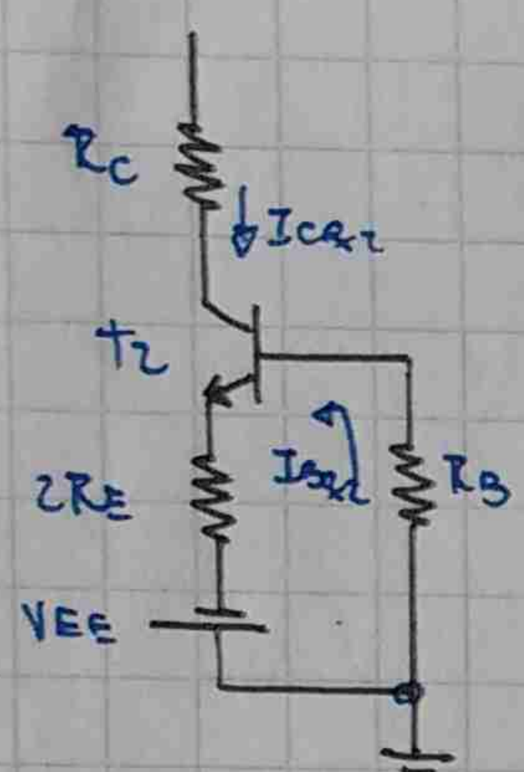
Amplificador Diferencial



$\boxed{I_{CQ1} = I_{CQ2}}$

$I_{RE} = I_{CQ1} + I_{CQ2} = 2I_{CQ1}$

$V_{RE} = 2I_{CQ2} R_E = I_{CQ2}\, 2R_E$



$I_{CQ2} = \dfrac{V_{EE} - V_{BE}}{2R_E + \frac{R_B}{\beta}}$

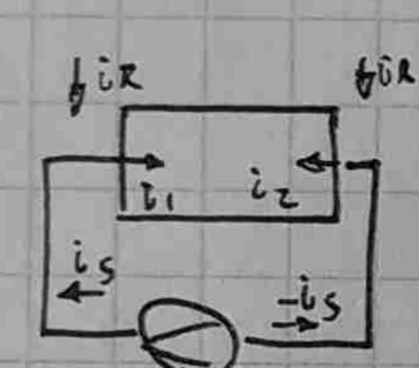
$V_{CEQ2} = 2V_{CC} - I_{CQ2}(R_C + 2R_E)$

Si R_C = (iguales) $V_{CEQ1} = V_{CEQ2}$

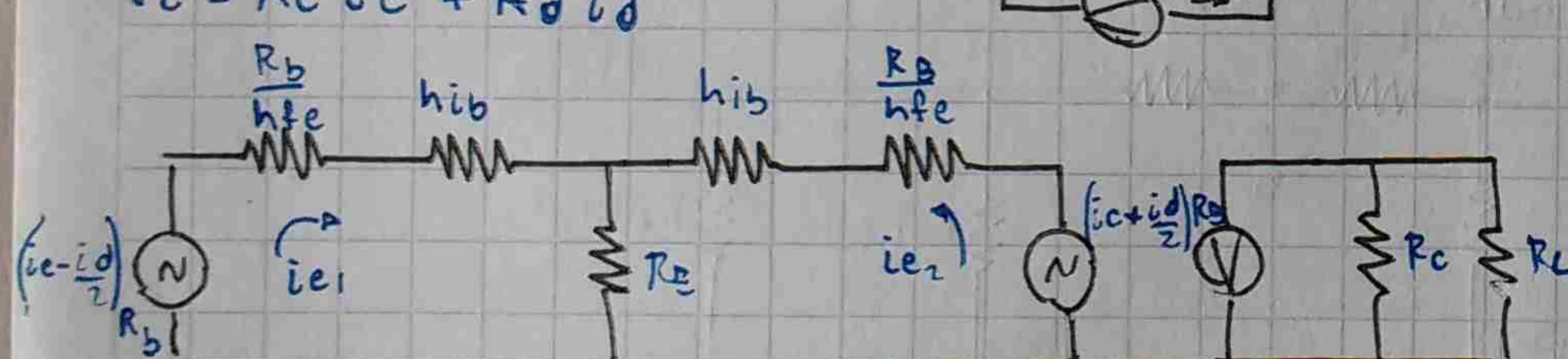
Modo Común. $i_c = \dfrac{i_1 + i_2}{2}$

Modo diferencial $i_d = i_2 - i_1$

$i_L = A_c i_c + A_d i_d$



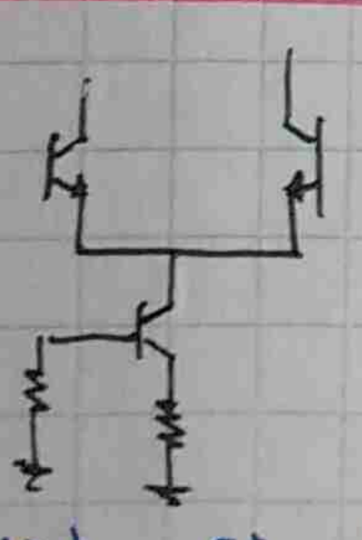
$\left.\begin{array}{l} i_c = i_r \\ i_d = -2i_s \end{array}\right\}$ $\begin{array}{l} i_1 = i_c - \frac{i_d}{2} \\ i_2 = i_c + \frac{i_d}{2} \end{array}$



Por superposición

$i_L = \underbrace{\left(\frac{-R_C}{R_C+R_L}\right)\frac{R_b}{2R_e + h_{ib} + \frac{R_B}{\beta}}}_{A_c} + \underbrace{\left(\frac{-R_C}{R_C+R_L}\right)\frac{R_B}{h_{ib} + \frac{R_B}{\beta}}}_{A_d} i_d$

Agregando un 3er trans.



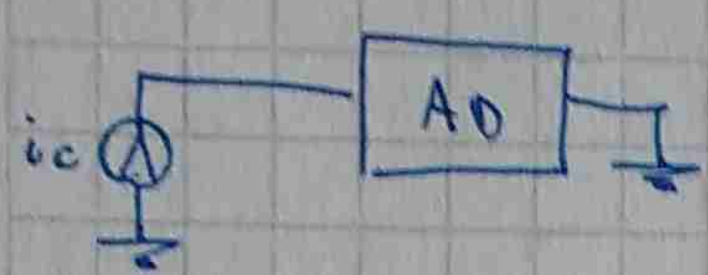
$\boxed{I_{CQ3} = \dfrac{V_{EE} - V_{BE}}{R_E + \frac{R_B}{\beta}}}$

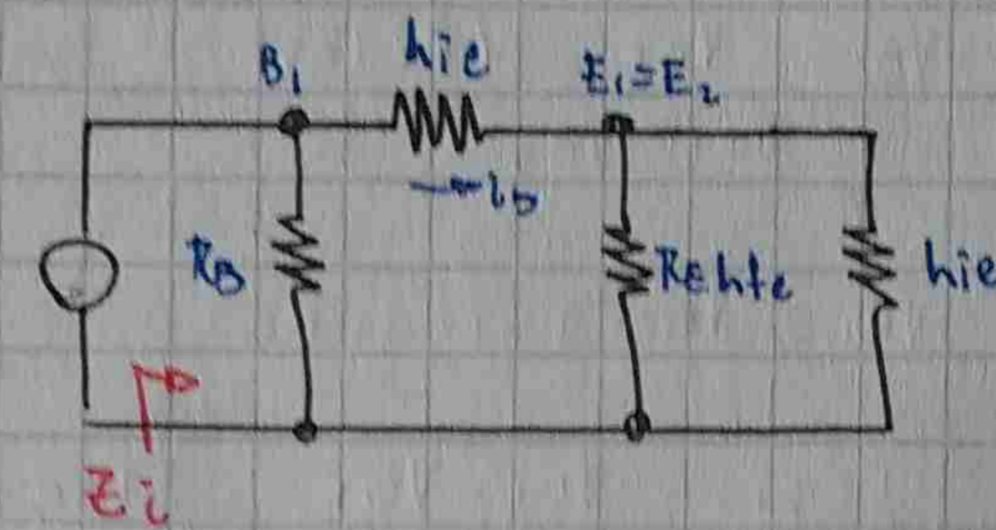
$\boxed{I_{CQ1} = I_{CQ2}}$

Salida simétrica

Impedancia entrada:

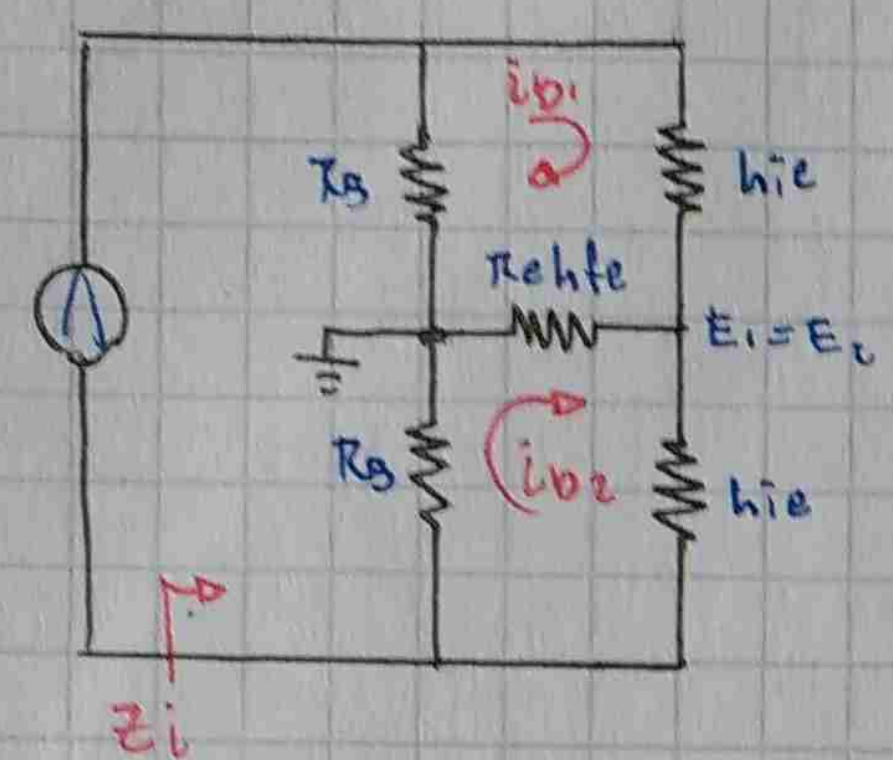
Asimétrica.



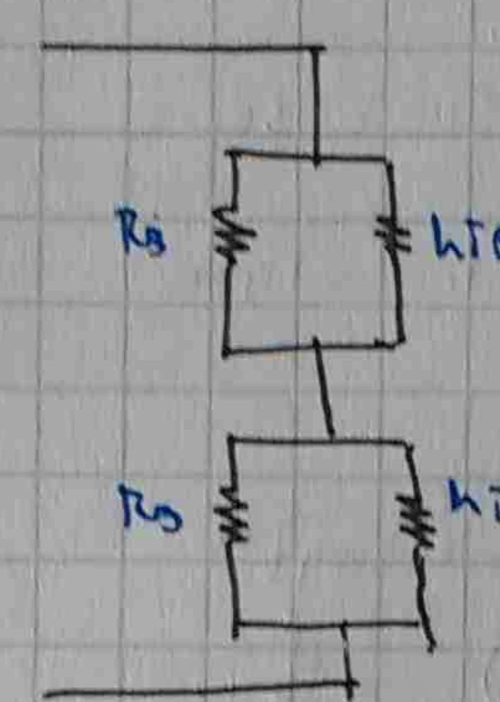


$Z_i =$

Simétrica

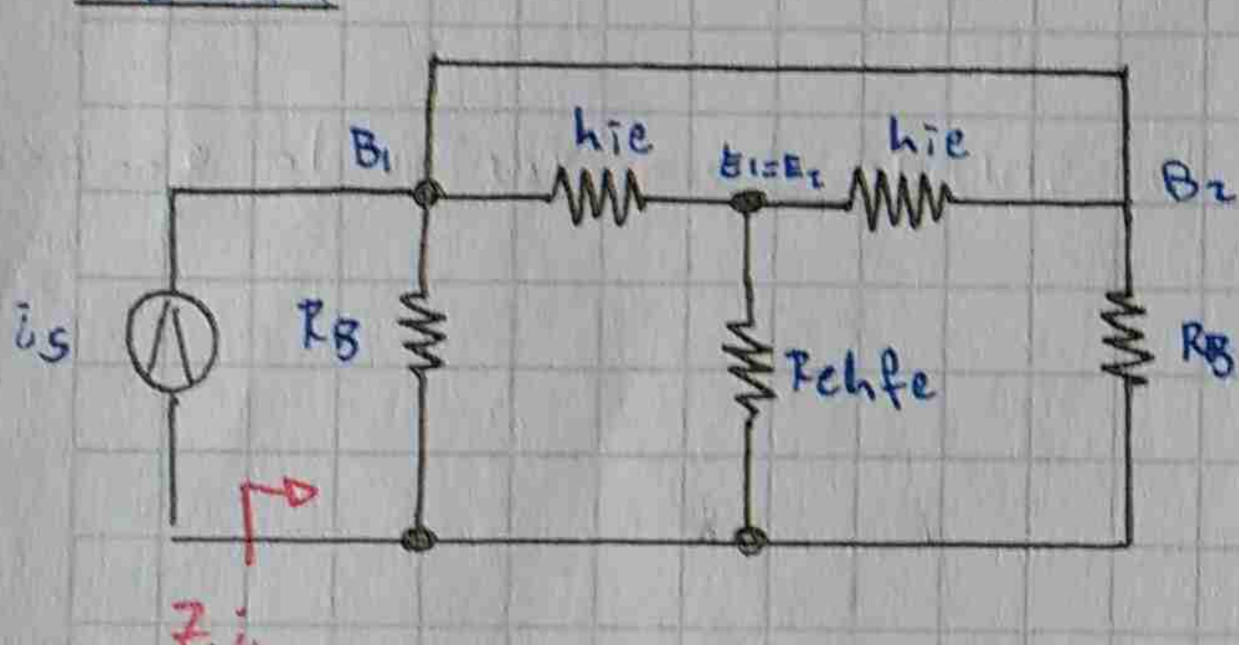


$\equiv$

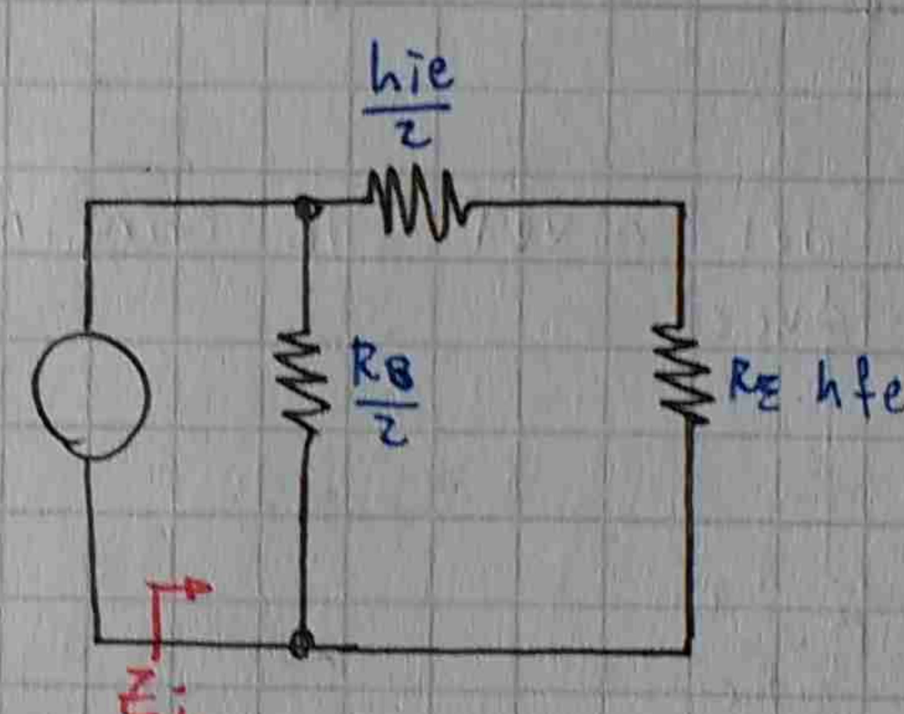


$Z_i = 2\left(h_{ie} // R_B\right)$

Común



$\equiv$

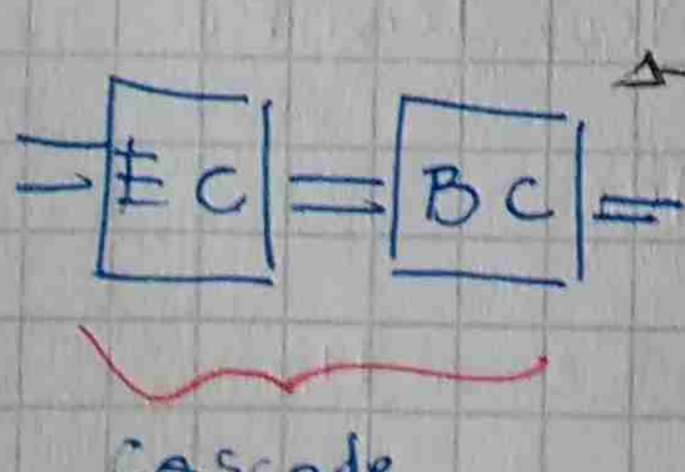


Amplificador Cascode

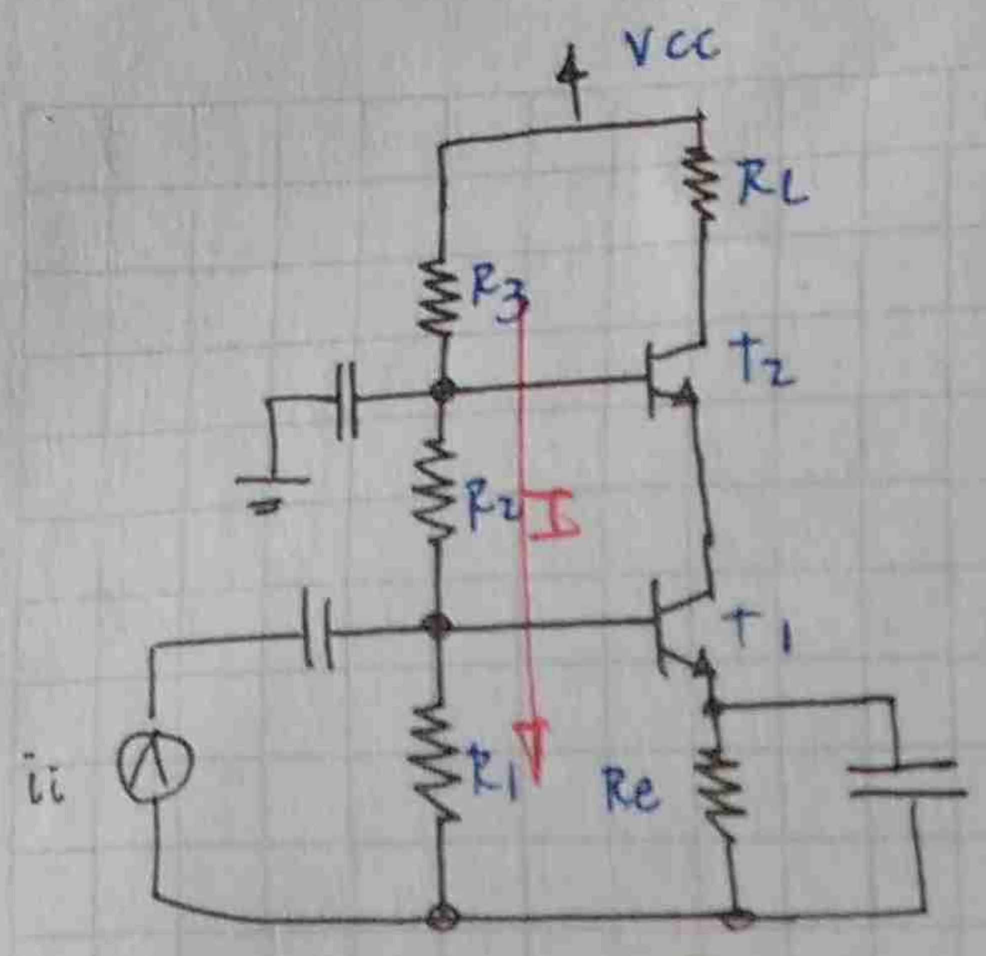
- Para evitar la disminución del ancho de banda debido a la realimentación por el cap interelectródico $C_M = C_{bc}\left(1 + g_m R_L\right)$

$C_M = f(R_L)$ etapa siguiente

1



Baja impedancia de entrada



$I \gg \begin{cases} i_{BQ1} \\ i_{BQ2} \end{cases}$

$V_{B2} = \frac{V_{CC}}{R_1+R_2+R_3}(R_1+R_2)$ $\qquad$ $V_{B1} = \frac{V_{B2}}{R_1+R_2} \cdot R_1$

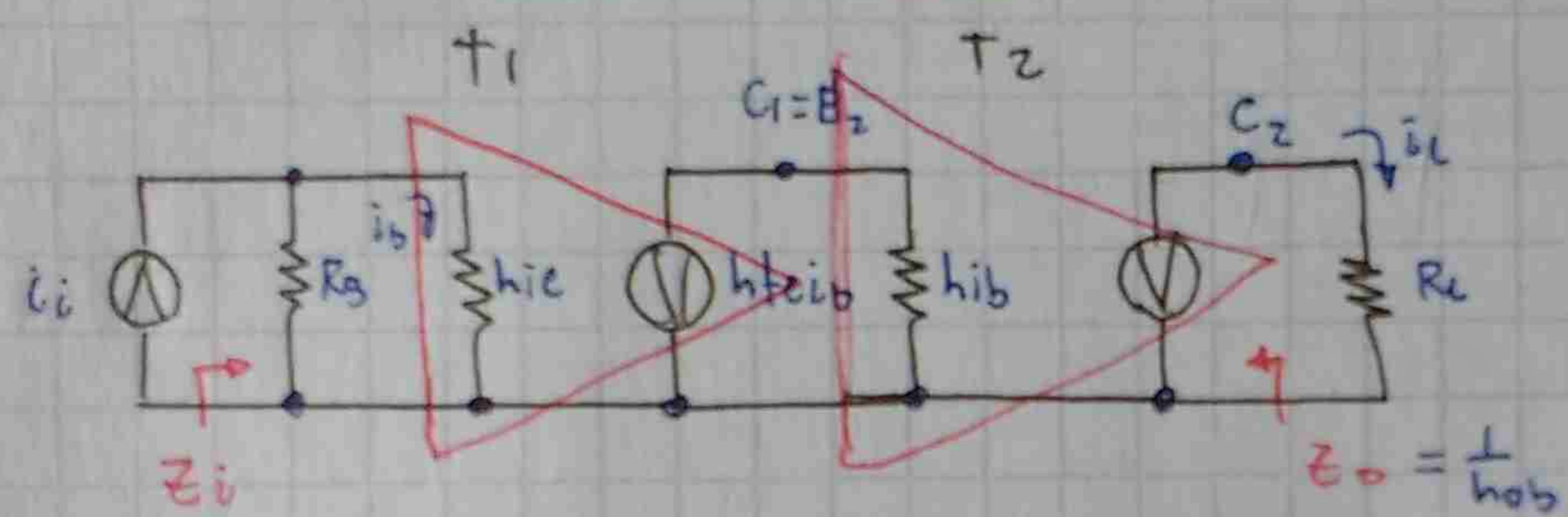
$V_{B1} = V_{BE} + I_{CQ1} R_e$

$\boxed{I_{CQ1} = \frac{V_{B1}-V_{BE}}{R_e} = I_{CQ2}}$

$\boxed{I_{BQ2} = \frac{I_{CQ2}}{\beta} = I_{BQ1}}$

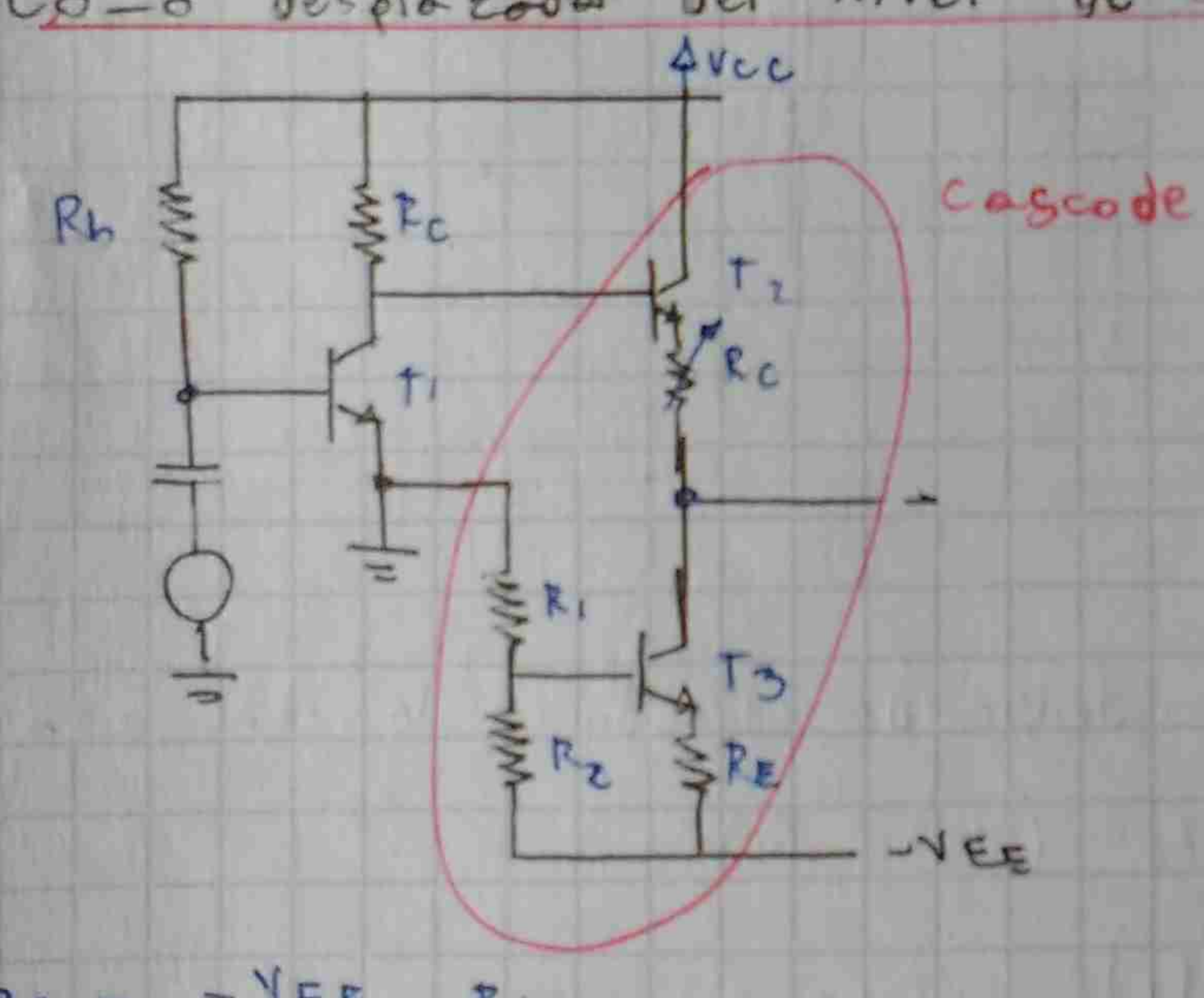
$\boxed{V_{CEQ1} = V_{B2} - V_{BE} - I_{CQ1} R_E}$ Vengo Desde la base.

$\boxed{V_{CEQ2} = V_{CC} - I_{CQ2}(R_L + R_E)}$ con lo anterior



Como desplazador del nivel de continua a la salida sin variar la ganancia Av

(2)



$V_{B3} = \frac{-V_{EE}}{R_1+R_2} R_1$

$V_{E3} = V_{B3} - V_{BE}$

$V_{E3} = V_{B3} - V_{BE}$

$I_{CQ3} = \frac{V_{RE}}{R_E} = \frac{V_{E3}-(-V_{EE})}{R_E} = I_{CQ2}$

$I_{BQ1} = \frac{V_{CC}-V_{BE}}{R_B}$

$I_{CQ1} = \beta I_{BQ1}$

$I_{CQ1} \gg I_{BQ2}$

$V_{B2} = V_{C1} = V_{CC} - I_{CQ1} R_C$

$V_{E2} = V_{B2} - V_{BE}$

$V_{E2} - I_{CQ3} R'_e = V_L$

$\boxed{R'_e = \frac{V_{E2}-V_L}{I_{CQ3}}}$ ← offset

NOTA